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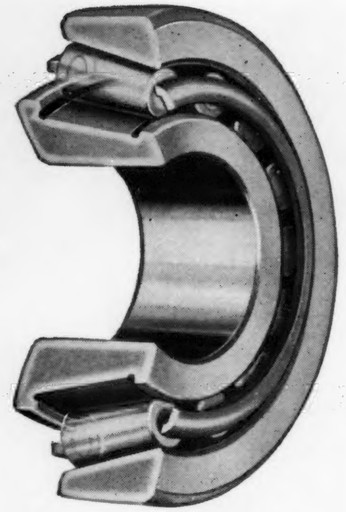

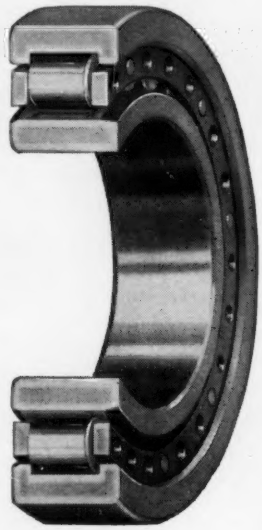

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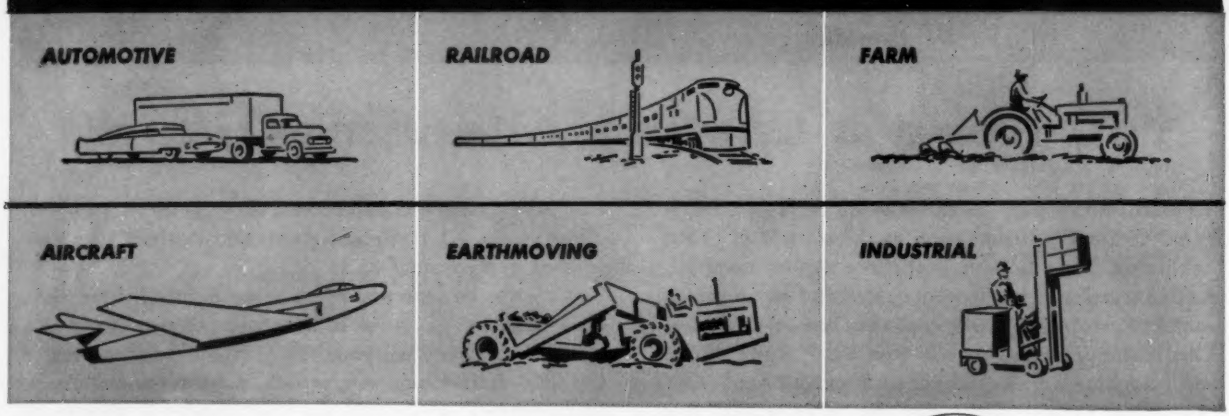

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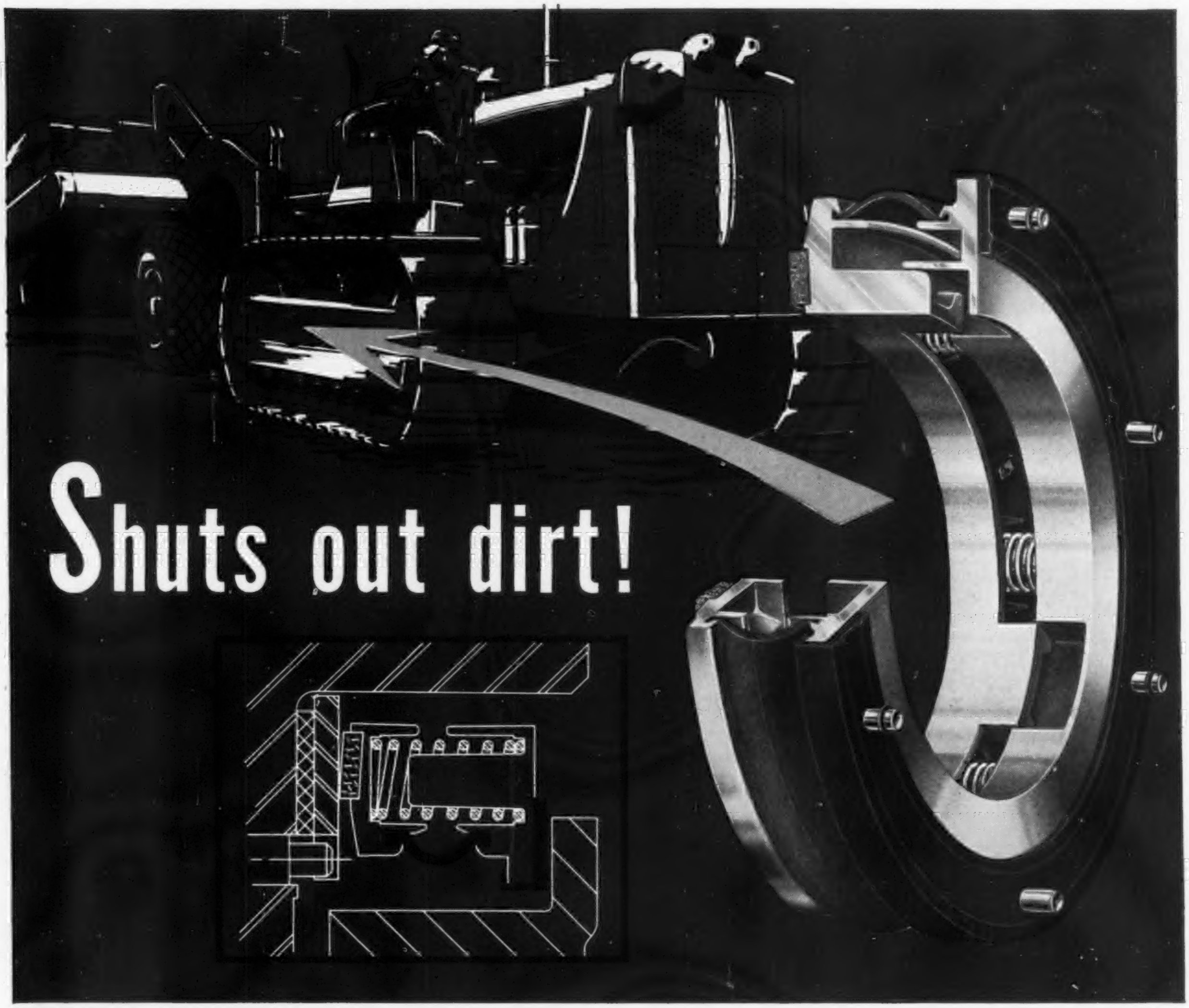
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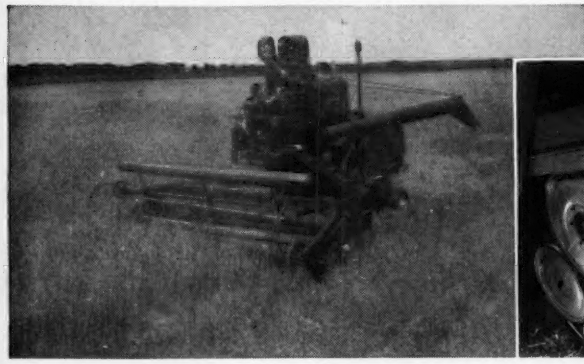

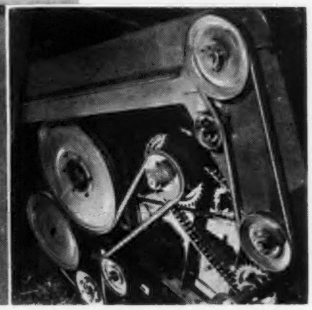

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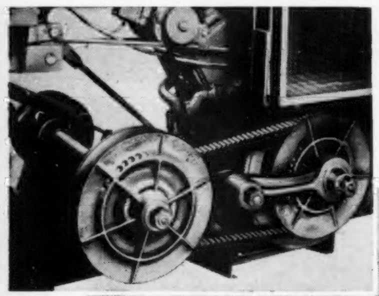

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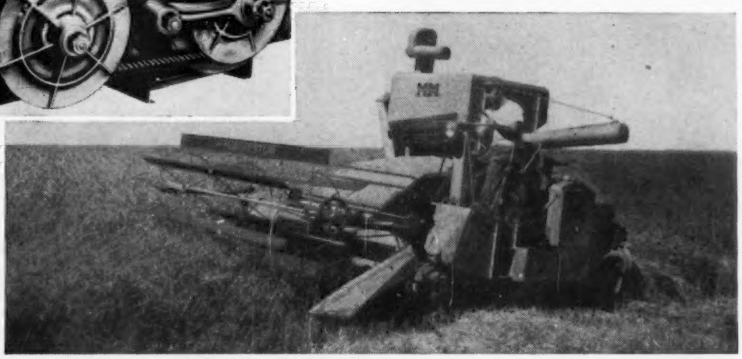

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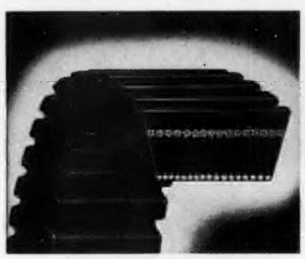

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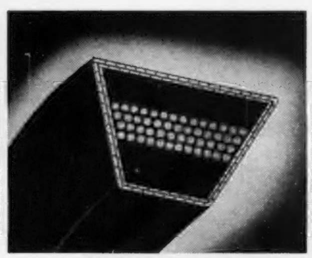

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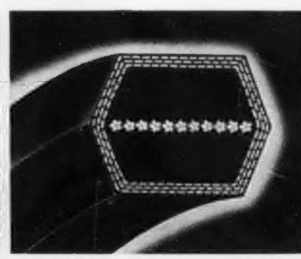

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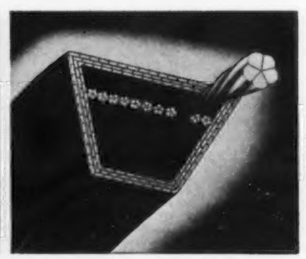

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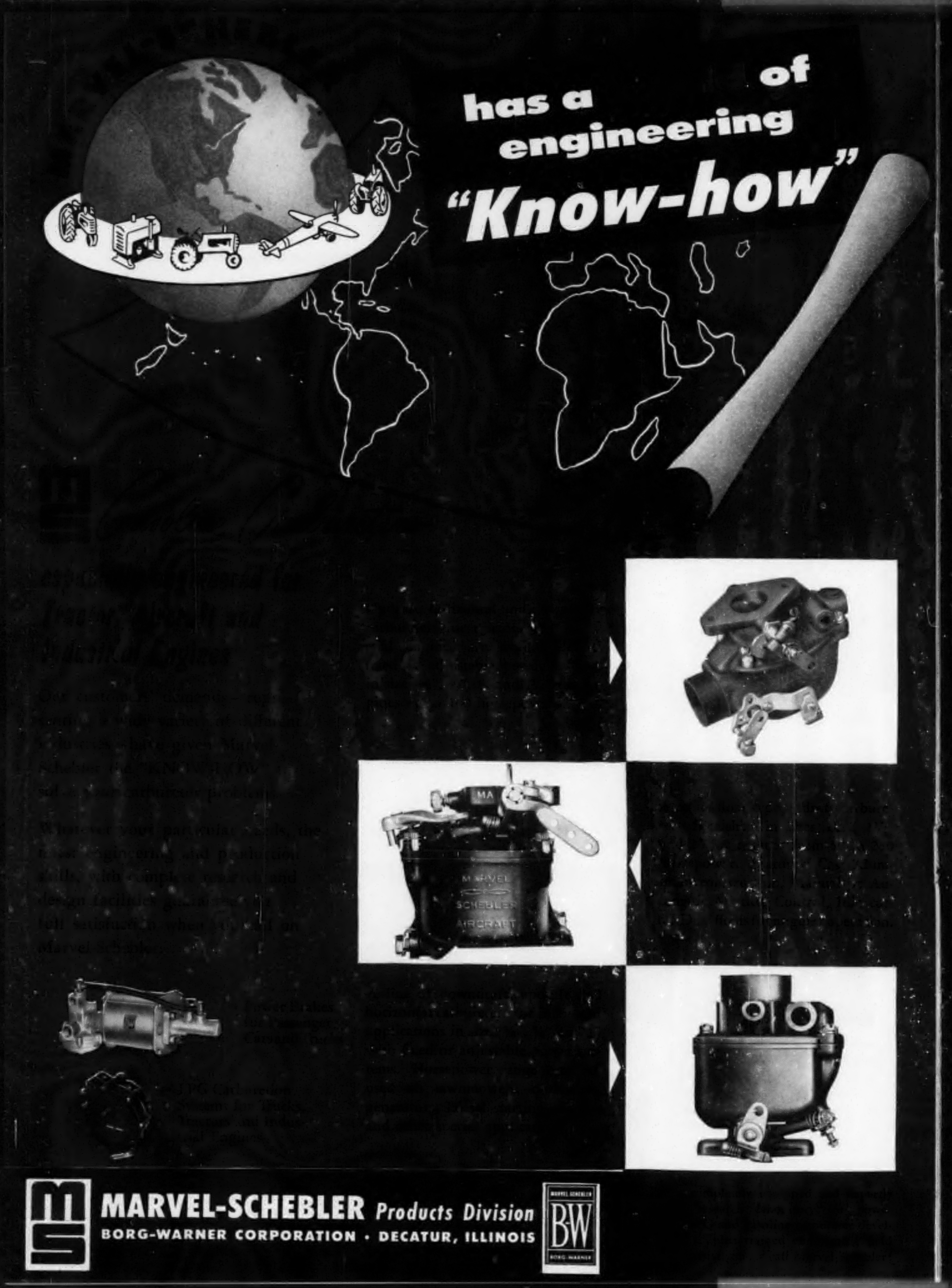
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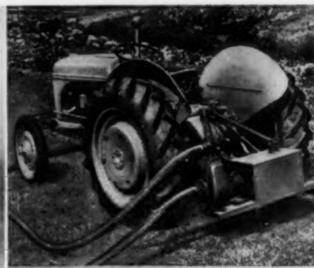

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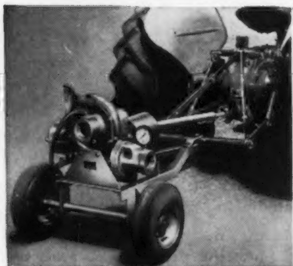

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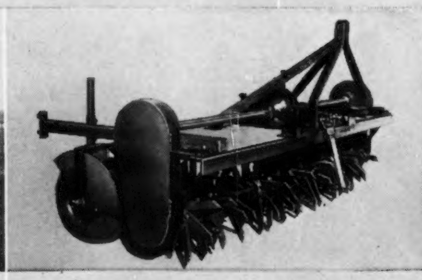

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AGRICULTURAL ENGINEERING

VOL. 36 JUNE, 1955 No. 6

College-Industry Cooperative Research

Roy Bainer
Fellow ASAE

Urgent need for pressing the attack on basic problems of quality of product, reduction in waste, unit operations, dynamics of machines, and the like points up the opportunity for highly rewarding results from expanding college-industry teamwork in agricultural research

COOPERATIVE arrangements for research, both formal and informal, have existed between industries serving agriculture and colleges and universities for many years. The trend today is toward increasing such activity. Time has not permitted the making of a survey of the many cooperative arrangements in existence. However, correspondence with twelve selected college agricultural engineering departments revealed an active interest in cooperative research and a desire for further expansion. Some of the companies and associations now cooperating on research problems mentioned in the correspondence included Aluminum Company of America, United States Steel Corp., Reynolds Metals Co., American Zinc Institute, Fiber Glass Division of Libbey-Owens-Ford Glass Co., Lawrence Paper Co., Electro-Aire, Inc., New York Canners and Freezers Assn., GLF Farm Supplies, Inc., New York Flower Growers Assn., Avco Mfg. Co., Gehl Bros. Mfg. Co., Edwards Equipment Co., J. I. Case Co., Tractor and Implement Division of Ford Motor Co., Deere & Co., International Harvester Co., Brillion Iron Works, The Ferguson Foundation, Jacklin Seed Co., Ryolex Corp., New Departure Division of General Motors Corp. and certain public utility companies.

No doubt the list of cooperators would have been much longer had the survey included all the publicly supported agricultural-engineering research groups. It was surprising and at the same time encouraging to find such a wide variation in cooperative effort.

In several instances, industry was supplying equipment or materials only. However, in about 80 percent of the cases reported, industry was also providing funds to assist with the work. Occasionally the financial arrangements included provisions for graduate fellowships or for the employment of additional engineering talent.

Probably the most outstanding cooperative research effort of long duration has involved the use of electricity in agriculture. Some of the state projects have continued for more than 25 years, and, in some instances, grants-in-aid in support of the work have amounted to as much as a quarter of a million dollars. It is needless to go into detail regarding the results of this activity. Certainly the use of electricity on farms has exceeded expectations and brought about a tremendous improvement in rural living. For example, slightly more than one-half of the 67,000 horsepower-hours of energy used annually on the average California farm come from the electric power line. In summarizing the value of the California project, Dr. Robert Gordon Sproul, president of the University of California, stated: "The research in the field of agriculture made possible by the contributions from the Committee on the Relation of Electricity to Agriculture during the past quarter century could well provide the subject matter for a book. The facts revealed by the research, and the confidence which has resulted from it, have made the California farmer one of the world's major users of electrical power, and contributed significantly to the state's ability to continue as the first or second highest agricultural producer in the nation."

Fig. 1 University of California agricultural-engineering research engineers catching material from the straw walkers and shoe on a combine equipped for harvesting corn. Later this material was analyzed for threshing and free seed losses

In 1928, Walker* defined the position of the experiment station and the farm equipment industry in regard to research. He said in part: "The development of equipment research in our experiment stations will be of service to those

Paper presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1954, on a program arranged by the Education and Research Division.

The author — ROY BAINER — is chairman, agricultural engineering department, and assistant dean of engineering, University of California (Davis).

*Walker, H. B. USDA Miscellaneous Publication No. 38. Research in mechanical farm equipment, December, 1928.

industries responsible for the manufacture of farm machines. In fact, the future of farm machinery development depends upon analytical research, many phases of which cannot be developed in industrial laboratories. The nature of modern industrial manufacturing is such that the farm-equipment industry cannot resort in any great measure to the field-exploitation method of development. Volume of production in the modern manufacturing plant is of primary importance. Before volume in production can be assured, the product must be of proven value, with its commercial applications quite well defined.

"In the case of some types of simple machines the factors which should be known in advance of production can be determined by laboratory studies, but in field-operating equipment such as new types of harvesting, tillage, and seeding machines, the factors of crops, soils, climatic conditions and plant diseases may be important in determining the future value of the equipment. To prepare a factory for large-scale production without taking into account these agricultural factors would be financially hazardous, and if the products were exploited to the agricultural producer through short-sighted sales methods, the ultimate results might prove a menace to our agriculture. It is true that the up-to-date implement factory should, and does, have experiment farms to test the operating characteristics and structural features of its products, but the determination of farm-machine requirements to meet special functions such as pest control, plant-disease control, fertilizer distribution, and similar situations, where the skill and scientific knowledge of the entomologist, plant pathologist or soils expert are necessary in addition to that of the engineer, is hardly within the scope of commercial research."

In general, the points brought out in Walker's analysis sum up the situation that exists today. Fortunately in the 25 years since Walker made his report the over-all research picture in publicly supported institutions has greatly improved. The number of workers has increased, more funds are available, and the training and experience of the research worker has improved. Although there is still considerable room for improvement, the agricultural engineer today is in a particularly good position to serve industry. In the experiment station he has the support of specialists in all of the major fields. He has recognized his dependence upon his colleagues and has been able to interest them in the cooperative solution of complex problems. He also understands their language and can interpret their viewpoint. The success of his undertakings has placed him in an enviable position on the experiment station team, with the result that generous resources are available to him. Not only can he handle the engineering phases of a problem, he is also able to serve as a coordinator with the other specialists involved.

As a general policy, the research worker in the experiment station should not attempt to develop and build equipment for direct use in agriculture. This, of course, hinges on the ability and willingness of industry to accept this responsibility. The experiment station worker, on the other hand, should be interested in the function of machines with respect to agriculture's basic needs. He should work with industry on problems that the latter is not in a position to handle. A good example may be taken from a cooperative agreement between the Avco Manufacturing Company and Cornell University. While the contact was made through the department of agricultural engineering of the University, other departments have been drawn in to get the complete information desired. Agronomy, animal husbandry, and botany are all contributing to a program of securing basic information on hay production. An economist might well have been included. Where, in industry, could a team like this be assembled?

Occasionally equipment must be developed at the experiment station level to meet local problems. In these situations full-line companies, as a rule, are not interested because of anticipated low volume. Smaller manufacturers frequently are unable or unwilling to risk the financial burden of development work. The latter group, however, is often in a position to make a new machine available as soon as basic information is developed. Usually a prototype machine is constructed by the experiment station, and once commercial production is undertaken, some consultation with the experiment station worker is required to insure the manufacture of a satisfactory final unit. These original developments often require the additional assistance of workers in the plant or animal science fields. The agricultural engineer, in this case, acts as the liaison agent between the parties in-

Fig. 2 Two views of experimental attachments developed by agricultural engineers and used in studies on adapting combines to harvesting corn. *(Left)* Lely attachment on a John Deere No. 55 combine • *(Right)* Snapping rolls attached to an International Harvester No. 64 combine

Fig. 3 Loading large bulk boxes of oranges with a tractor equipped with a fork lift — part of a study made by UC agricultural engineers, in cooperation with the citrus industry, on the possibilities for bulk handling of fruit

volved. Some typical examples are mentioned in the following paragraphs:

For several years the dried fruit industry of California urged the University to develop a mechanical apricot cutter. Their efforts to interest industry had failed. The key to the development was learning how to orient the fruit so that the sutures of the apricots would fall in one plane. The prototype machine that was eventually developed incorporated these features: the singling and orientation of the fruit; a cutting mechanism that compensated for variations in diameter; pit rejection, and final orientation of the cut fruit on the drying tray with the cup side up. Once the prototype was achieved, it was not difficult to interest a local manufacturer in building the machine.

Before an electronic color sorter could be developed for handling fruit and vegetables, some phenomenon varying with ripeness of the fruit had to be established. Scientists at the USDA Western Regional Research Laboratory aided in developing this information. Reflectance tests, made with the aid of a spectrophotometer using the complete range of the spectrum, showed a sharp dip in the reflectance curves for green lemons, for example, at a wave length of light of 6780 Angstrom units (red region of the spectrum). This dip was due to the high absorptivity of the surface chlorophyl in this region of the spectrum. Therefore, the response for yellow lemons was nil, while a maximum distortion of

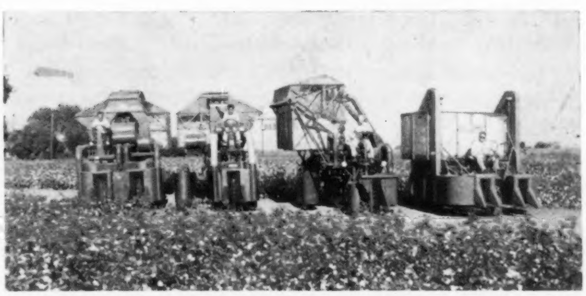

Fig. 4 These four spindle-type cotton pickers were furnished by four manufacturers (Deere & Co., International Harvester Co., Ben Pierson Co., and Allis-Chalmers Mfg. Co.) for comparative field-testing purposes. The tests were a part of the cooperative programs of the U.S. Department of Agriculture and the University of California on cotton mechanization

the curve occurred for dark green lemons. The ratio of reflectance between these two extremes was 8 to 1. Fruit at intermediate stages of ripeness fell between these extremes. The establishment of this basic information was the key needed for the engineering solution of the problem, and a prototype machine capable of sorting four to five lemons per second was then built and field-tested. In establishing the basic information it was found that it took only 1/100 second to make a reading of an individual fruit. A machine, therefore, could be expected to sort at a much higher rate if the mechanics of introducing and discharging one fruit at a time could be speeded proportionately. A university-developed prototype solved the basic problem, and the machine that is now under commercial development has gone a step farther—its operating goal is set for 40 lemons per second (the equivalent of 10 field boxes per minute).

For many years the beet sugar industry tried to interest the implement industry in developing equipment for mechanizing sugar beet production. Aside from one development—which was not applicable under all field conditions—there was nothing available commercially. As a result, the United States Beet Sugar Association underwrote an over-all project on mechanization to be handled jointly by the University of California and the U.S. Department of Agriculture. When basic information was made available on seed processing, treating, planting, blocking and thinning, topping, and harvesting, several companies began to show an active interest in the problem. As soon as industry indicated its willingness to undertake a development program, the federal and state workers withdrew. Knowing when to turn such an endeavor over to industry is important. This particular arrangement worked out satisfactorily.

In most cases, such as the three examples referred to, commodity groups have assisted financially in initiating the projects through grants-in-aid. Frequently an informal agreement has been developed. The sugar beet mechanization program was carried on under a contract. In this case a provision was made for the assignment of patents to the United States Beet Sugar Association.

Departments of agricultural engineering throughout the United States have made worth-while contributions to the mechanization of agriculture. Floyd W. Duffee and his associates at the University of Wisconsin have excelled in their work on equipment for harvesting and cutting forage. Harris P. Smith at the A. & M. College of Texas has been the leader in the development of the cotton stripper. At North Carolina State College basic work has been done on the wheel-type rake. Commendable work has been done on the mechanization of potato harvesting at the University of Idaho and the University of Maine. George E. Pickard and his associates at the University of Illinois are doing basic work on the shelling of corn with combine cylinders. The University of Nebraska has a world-wide reputation in its service to industry through its tractor-testing program. Arthur W. Clyde of Pennsylvania State University has done outstanding work in his studies on hitching and on the dynamics of machines. Sugar beet machinery investigations (cooperative with the U.S. Department of Agriculture) have been centered at Michigan State College, Colorado A. & M. College, and University of California. Iowa State College has made worthwhile contributions to corn planting and harvesting. Kansas State College has been doing important work with

the heat pump. Ohio State University has made exhaustive tests on threshers and combines. Small-seed legume harvesting studies have been made at Clemson Agricultural College and the University of California. This list could be extended to cover most of the commodity fields, but space does not permit mention of the splendid work going at all experiment stations.

Since industry today seems to be trying to keep in closer touch with what is in progress at the experiment stations, a survey and catalog of research activities at the numerous publicly supported institutions should be of considerable value. Such a survey would provide short cuts to the institutions best qualified to handle specific problems requiring cooperative effort.

Until recently direct industrial cooperation has been largely limited to the lending of equipment for studies that industry has initiated. Lately, however, some impetus has begun to come from the experiment stations, and industry has responded with other kinds of assistance. For example, in the legume-seed harvesting work at the California experiment station certain problems arose during studies to adapt combines to handle clover seed. Assistance was requested from the manufacturer of a combine in general use, who assigned one of his engineers to work with the experiment station staff. This cooperative effort resulted in a satisfactory solution.

During the past year machinery manufacturers were asked to cooperate on a corn-harvesting project in California by developing gathering attachments that would make their combines suitable for corn harvesting. While all did not respond, three cooperators did make and operate their equipment in corn in 1954. The first year's trial was encouragingly successful. It is apparent that California corn can be combined successfully. This was an ideal arrangement in that manufacturers designed, built, and operated all of the necessary equipment. The experiment station staff arranged for farmer cooperators and made detailed studies of machine performance and the quality of the output. Both the agricultural engineering and the agronomy departments cooperated with industry on these projects.

Teaching and research go hand in hand. Creative research is the mechanism through which the university can fulfill its primary aim, that of enlarging man's understanding. Today industry expects creativeness in its new employees. The students in agricultural engineering must not only be well grounded in principles and practices, they must also be trained in an atmosphere of creativeness. To give them adequate training, the instructors must have the opportunity to be creative, for the teacher who is not himself creative cannot develop such ability in the student. Cooperative research, affording the opportunity for both creative thinking and a better insight into industry's problems, is a promise of more effective work from the teachers as well as from the students who will be the industrial leaders of tomorrow.

Industry's establishment of graduate fellowships offers one of the most promising means of carrying on cooperative research and at the same time aiding the teaching program. The problems to be studied should be basic to industry. The fellowships might be restricted to promising men with three to five years of experience in industry, or to outstanding seniors who want to further their education. In the latter case, industry as well as the university staff has a splendid opportunity of sizing up the student's creative ability and estimating his chances of success in industry.

Industry and agricultural engineering departments have one thing in common. Both need men with more experience and training to solve today's increasingly complex problems. Academic training beyond the baccalaureate degree is the logical answer.

Those in research institutions supported by public funds should take inventory of their research programs. Some revision is no doubt desirable. To be of most value to industry the research should be basic in nature and well coordinated with the over-all objective of agriculture. One pitfall to avoid is that of becoming simply a testing station.

One of the large fields for intensive research is the improvement in quality of products handled under a mechanized production program. There is hardly a crop that does not show some decrease in quality when production is mechanized. Cotton is a typical example. Mechanization of the harvest has resulted in lowering the quality by one or more grade points. The solution to this problem may be in the hands of the botanist, who is striving to defoliate the crop properly before harvest to reduce the trash content of the lint; or the answer may come from the plant breeder who is working toward the development of a self-defoliating plant, or a rearrangement of bolls to get them off the ground. The weed specialist may be able to help the trash problem through improved weed-control practices. Certainly a coordinated program involving many scientists will be necessary to get a final answer.

Crop losses are staggering. These include harvest losses as well as those of storage and processing. Losses resulting from mechanization of the corn crop are appalling. Concerted effort on the part of research teams composed of workers in industry and the experiment station, including the plant breeders, is desirable.

Walker† has stressed the need for a balanced research program. He summed up the situation as follows: "Progress in agricultural engineering, to date, has been attained principally by the labor-saving route. . . . This has called not only for applied research, but also for development and surveys of practice. Labor saving in agriculture is still of significance, but the mechanical techniques for reducing labor for standard field operations are receiving increased attention by competent research departments in industry. . . . During the past 25 years our experiment stations have spent considerable effort on equipment development. . . . This has been justified, but the question may be raised now, if agriculture, and the industries serving agriculture, might not be better served if more attention were devoted to basic studies relating to product quality, reduction in waste, dynamics of machines, fluid mechanics problems, unit operations and the like. . . .

"It should be a primary object in equipping for basic research to assemble staffs of great ability and high academic achievement. Surely our non-profit institutions, if they are to fulfill their responsibility for creating new knowledge, must assemble staffs containing a goodly number of highly trained men."

We must remember that research is the price of survival. How well we survive will depend upon the quality of our research.

†Walker, H. B., Balancing agricultural engineering research, AE, July, 1954.

Determining When to Irrigate

W. O. Pruitt and M. C. Jensen
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Agricultural-engineering studies comparing actual consumptive use of irrigation water with evaporation from a free-water surface and with estimated consumptive use by the Thornthwaite and the Blaney-Criddle procedures produced results that show promise for the evaporation-pan method

THE need for a practical way to determine when to irrigate has long been recognized. One of the most effective ways to increase irrigation efficiency on the farm is to provide the farmer with a convenient method with which he may recognize the proper time to irrigate his crops. Various devices have been developed for this purpose. Electrical-resistance-type moisture blocks and moisture-tension equipment are among the more important, and these methods have been very useful in research. They have not, however, been widely adopted by farmers.

An indirect approach to the problem involves the use of climatological data to estimate consumptive use. Blaney and Criddle (1)* developed a procedure for estimating monthly and seasonal consumptive use from temperature, daylight hours, and crop information. This procedure has been used recently by several state experiment stations to estimate monthly and seasonal consumptive use and irrigation requirements for local areas within individual states (2, 3, 4, 5, 6). Two states have proposed techniques for adapting the procedure to obtain peak daily consumptive-use rates for irrigation-system design (3, 4). Thornthwaite (7) developed a procedure for estimating consumptive use from information on temperature, latitude, days per month, and an index established locally. His purpose was to classify climate. Others (8) have used Thornthwaite's procedure for estimating daily consumptive-use rates as a guide for determining the time of irrigation. Penman (9) studied losses by evaporation from open water surfaces, bare soil and turf in England. He developed a procedure which used several climatic factors to determine consumptive use. These procedures have all received widespread recognition.

Recently consumptive-use values determined from studies on several crops at the Washington Agricultural Experiment Stations have been compared with rates of evaporation from a free water surface. Results indicate that it may be entirely feasible for a farmer to use an evaporation tank on his farm to tell when to irrigate.

This report covers comparisons of actual consumptive use for four crops at Prosser, Wash., with tank evaporation and with estimated consumptive use computed by the Thornthwaite and the Blaney-Criddle procedures. Comparisons could not be made with Penman's procedure because some of the weather data used in his method have not been recorded.

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Acknowledgments: Aldert Molenaar, formerly professor agricultural engineering, initiated project 747 and was leader until 1952. C. E. Domingo, soil scientist, has recorded weather data since 1948. Allen Busenbark, senior experimental aide, has done much of the project field work since 1953.

*Numbers in parentheses refer to the appended bibliography.

Procedure

All crops were grown on a Ritzville very fine sandy loam ranging in depth from 3½ to 5 ft. This soil is underlain by an extensive layer of basalt rock which is relatively impermeable. Consumptive use was evaluated through use of soil-moisture samples taken from the entire profile from the surface to the rock. The amount of water applied each irrigation was carefully controlled to avoid overapplication and consequent free water at the rock surface. It is believed there was little opportunity for either lateral drainage or deep percolation. One exception was the 1949 alfalfa study when varying amounts of water were added at a regular frequency. Analysis of 1949 data showed some plots to be well above field capacity after irrigation. Data from these plots were omitted when average consumptive-use values were calculated.

Moisture treatments were planned on wet, medium, and dry criteria. It was intended that the medium level provide moisture for maximum yields. Time of irrigation was determined by periodic moisture sampling. Consumptive use was determined by measurng loss of moisture from the entire soil profile between irrigations and adding to this quantity any rainfall occurring during the period. Moisture samples were taken approximately one day before irrigation and from two to four days following irrigation. The average daily consumptive use between any two irrigations was determined by dividing the moisture loss plus rainfall by the number of days between samples.

The evaporation data were taken from a tank located approximately 3 miles due south of the experimental site in an environment similar to the experimental area. The tank is 6 ft in diameter, 2 ft deep, and set with the rim about 2 in above the ground surface. The surrounding surface of the weather station area has been built up by soil deposition until it is about as high as the top of the tank. The water level in the tank was maintained between 2 and 4 in from the top of the tank rim.

The Blaney-Criddle procedure can be expressed as $u = Ktp$ and $U_b' = \Sigma u$, in which u is monthly consumptive use in inches of water, K is a crop coefficient, t is mean monthly temperature in degrees Fahrenheit, p is monthly percent of annual daytime hours (sunrise to sunset), U_b' is seasonal consumptive use in inches of water, and Σu is the sum of the monthly consumptive uses during the crop growing period.

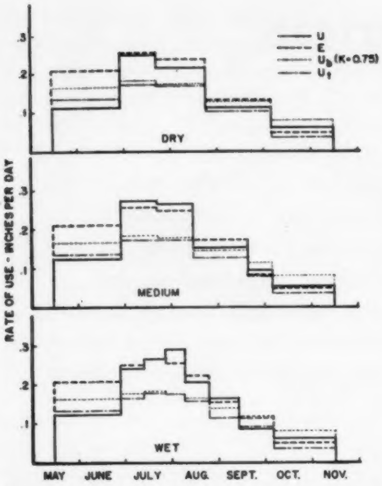

Fig. 1 Rates of consumptive use, U; evaporation, E; Blaney-Criddle estimated consumptive use, U_b, and Thornthwaite estimated consumptive use, U_t, for sugar beets grown under three moisture treatments in 1951

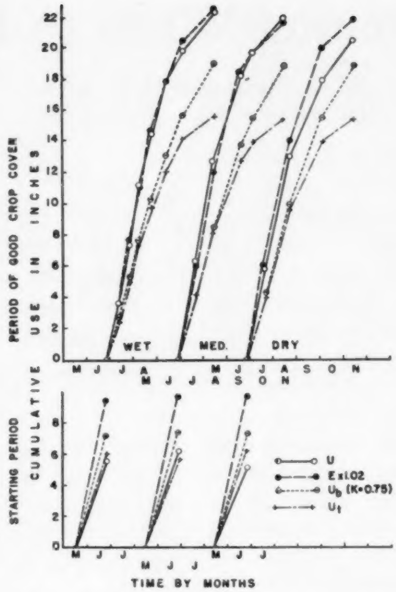

Fig. 2 Cumulative U, E x 1.02, U_b, and U_t for 1951 sugar beets from emergence to June 27 and from June 27 to date of harvest

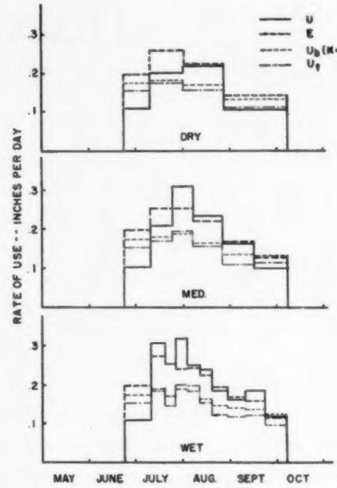

Fig. 3 Rates of consumptive use, U; evaporation, E; Blaney-Criddle estimated consumptive use, U_b, and Thornthwaite estimated consumptive use, Ut, for late potatoes grown under three moisture treatments in 1952

In order to compare this procedure with periodically measured consumptive use and evaporation, the t and p values were actually taken on a daily basis and summed for the measurement period.

The Thornthwaite procedure can be expressed as $e=1.6(10t/I)^a$, in which e is the monthly unadjusted potential consumptive use (Thornthwaite's potential evapotranspiration), t is mean monthly temperature in degrees Centigrade, I is a heat index for a location, and a is approximately 0.5103. The equation is solved by use of nomograms and tables and the unadjusted potential consumptive use is adjusted for the length of day and number of days in the month. In order to compare this procedure with measured consumptive use and evaporation, Thornthwaite's adjusted potential consumptive use was computed on a daily basis and summed for actual days involved in the measurement periods.

The following symbols will be used:

U = measured consumptive use.

E = evaporation from USDA BPI tank.

U_b = estimated consumptive use (rate or quantity) computed by the Blaney-Criddle method

U_t = estimated consumptive use (rate or quantity) computed by the Thornthwaite method.

The following example demonstrates how the comparisons were made. Two sets of soil samples, one taken two days after irrigation and another ten days later (one day before the next irrigation) indicate an average rate of loss of 0.2 in of water per day for the ten-day period. In order to show continuous graphs, this 0.2 in per day was assumed to

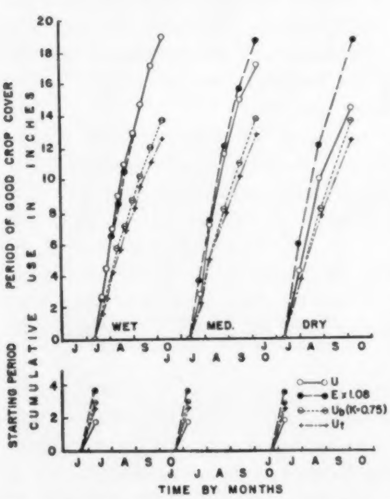

Fig. 4 Cumulative U, E x 1.08, U_b, and U_t for 1952 late potatoes from emergence to July 10 and from July 10 to the end of the growing season

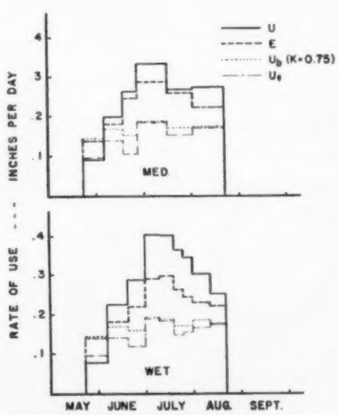

Fig. 5 Rates of consumptive use, U; evaporation, E; Blaney-Criddle estimated consumptive use, U_b, and Thornthwaite estimated consumptive use, U_t, for early potatoes grown under two moisture treatments in 1953

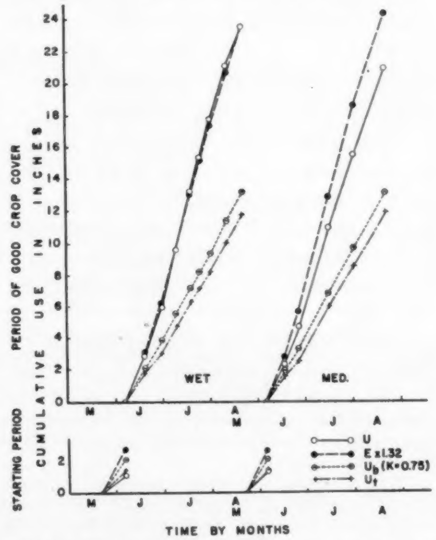

Fig. 6 Cumulative U, E x 1.32, U_b, and U_t for 1953 early potatoes from emergence to June 6 and from June 6 to the date of harvest

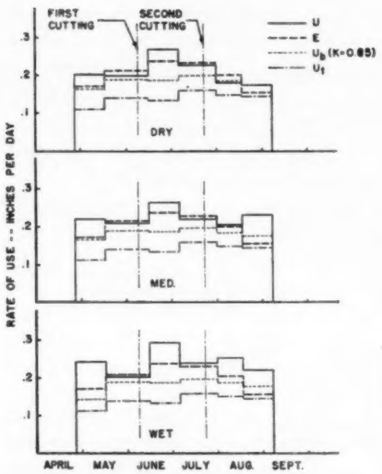

Fig. 7 Rates of consumptive use, U; evaporation, E; Blaney-Criddle estimated consumptive use, U_b, and Thornthwaite estimated consumptive use, U_t, for alfalfa grown under three moisture treatments in 1949

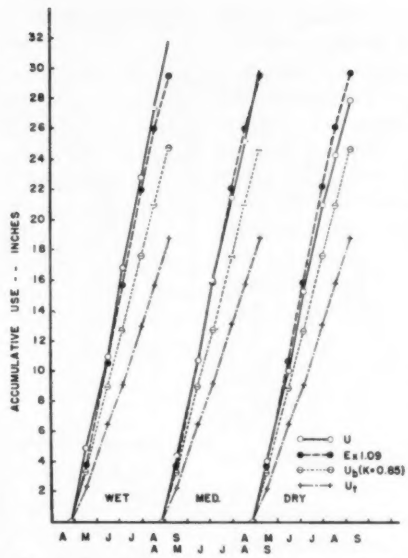

Fig. 8 Cumulative U, E x 1.09, U_b, and U_t for 1949 alfalfa (April 26 to September 7)

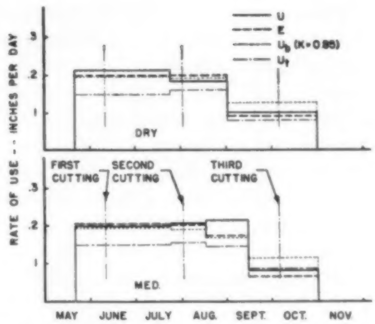

Fig. 9 Rates of consumptive use, U; evaporation, E; Blaney-Criddle estimated consumptive use, U_b, and Thornthwaite estimated consumptive use, U_t, for alfalfa grown under two moisture treatments in 1950

be the consumptive use rate for the entire 13 days between irrigations. To be comparative, average rates of E, U_b and U_t for the same ten days were used for the 13-day period. Consequently cumulative curves for E, U_b and U_t are slightly different for different moisture treatments.

Results

Measured consumptive-use rates for four crops are compared with tank-evaporation rates and rates of U_b and U_t in Figs. 1, 3, 5, 7 and 9. Corresponding cumulative curves for U, U_b and U_t, and for evaporation rate modified by a crop factor are shown in Figs. 2, 4, 6, 8 and 10.

For the first measured period between samplings, the value of U for sugar beets and potatoes is considerably lower than average tank evaporation; whereas, in almost all later periods, consumptive-use rates are about equal to or greater than evaporation. Since at the start of the first period the plants were very small and provided little ground cover, the lower consumptive-use rates during this time are reasonable.

In Figs. 2, 4 and 6 cumulative values have been broken down into two main parts, the crop-starting period and the subsequent period of good crop cover. The starting-period quantities were plotted separately in order to begin the graphs for periods of good crop cover at a common base. This was not done for alfalfa (Figs. 8 and 10) since the crop established complete ground cover early in the growing season.

In Figs. 2, 4, 6, 8 and 10, actual evaporation was multiplied by a crop factor. The factor was obtained by taking the cumulative total of U for the period of good crop cover and dividing by the actual evaporation for the same period. Only one factor for each crop was used. It was based on the moisture treatment found to be adequate for maximum yields. This included the medium treatment for sugar beets, wet treatment for both potato crops, and medium treatment for both alfalfa crops.

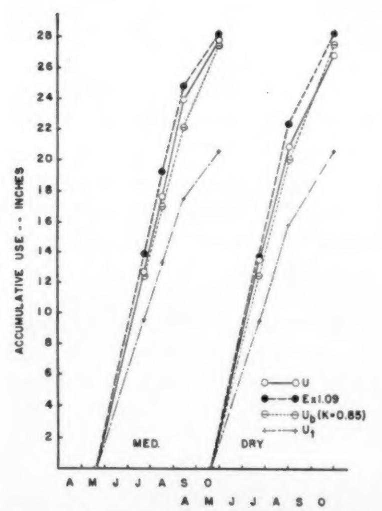

Fig. 10 Cumulative U, E x 1.09, U_b, and U_t for 1950 alfalfa (May 20 to October 31)

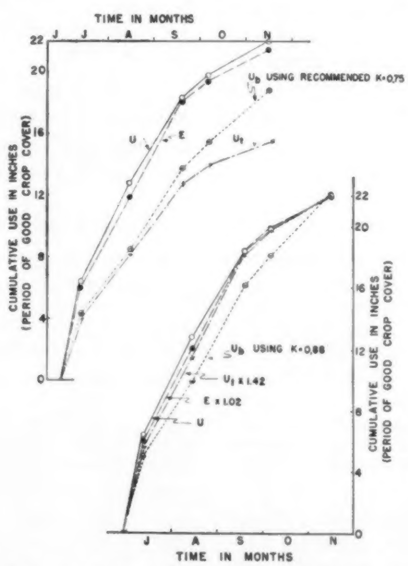

Fig. 11 Effect of applying constant factors to evaporation, E; Blaney-Criddle estimated consumptive use, U_b, and Thornthwaite estimated consumptive use, U_t, to more closely approximate actual consumptive use, U (1951 sugar beets, medium irrigation treatment, Prosser, Wash.)

Tank Evaporation as an Estimate of Consumptive Use

By noting the treatments for maximum yields in Figs. 1, 3, 5, 7 and 9 (medium for sugar beets and alfalfa, and wet for potatoes) the consumptive use is more nearly approximated by evaporation than by U_b and U_t. When a crop factor is applied to evaporation rate in Figs. 2, 4, 6, 8 and 10, consumptive use is closely duplicated.

The ratio between U and E for alfalfa changes somewhat throughout the season, probably due to the effect of cutting. During periods when a cutting was taken off, the results con-

sistently show a drop in the ratio between consumptive use and tank evaporation as compared with periods when no cuttings were removed. Since essentially all the foliage is removed each cutting, there is little chance for transpiration to take place for several days until regrowth has occurred. For the wet treatment, average ratios of about 1.3 to 1 for periods not including a cutting were found. This corresponds rather closely with results from another study made during July, 1952 (10). During a 19-day period the total consumptive use of alfalfa was 38 per cent greater than total tank evaporation. Although this 1952 work was basically a field study of the unsaturated flow of water in soils, consumptive use was calculated from the available data. Twenty comparisons, ranging from one-day intervals up to the total 19-day period, showed a regression equation of $U = 1.38E$ with a highly significant correlation coefficient of 0.99.

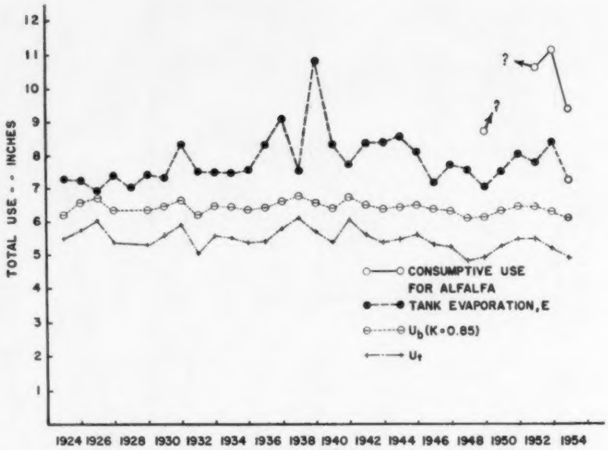

Fig. 12 Totals of E, U_b, and U_t for the month of July from 1924 through 1954 and measured consumptive use, U, for alfalfa for July of 1949, 1952, 1953, and 1954

Estimated Consumptive Use Based on Climatic Factors

The seasonal U_b for sugar beets was 26.2 in of water whereas actual consumptive use for the medium treatment was 27.0 in as shown in Fig. 2. This indicates that for the season total the Blaney-Criddle formula was relatively precise. However, from Fig. 1 it can be seen that the underestimation of actual use in midseason has been counterbalanced by overestimation during other parts of the season, especially during the period following plant emergence.

Except for the first measured period, U_t for sugar beets runs consistently low, and for the entire season falls behind actual consumptive use totals 6½ in for the medium treatment.

For the late potatoes (Figs. 3 and 4) results were similar to those for sugar beets. Taking the wet treatment only, which significantly outyielded the other two (18.6 T/A), cumulative U_b and U_t for the period of good crop cover fell short of actual consumptive use by 5.0 and 6.4 in, respectively, during the good crop cover period. These differences are decreased when the starting period (the period prior to good crop cover) is included. The difference between values for estimated and actual consumptive use was greater for early potatoes (White Rose) as shown in Figs. 5 and 6. In the wet treatment, which gave the best yield, (19.1 T/A) U_b and U_t values were only about 60 and 54 percent, respectively, of actual consumptive use.

From Figs. 7, 8, 9 and 10 it is apparent that U_t is seriously under actual consumptive-use values for alfalfa at this location. The Blaney-Criddle method was somewhat better for alfalfa than for sugar beets or potatoes.

Figs. 2, 4, 6, 8 and 10 suggest that a crop factor might be applied to U_b and U_t and make them more nearly approximate actual consumptive use. Fig. 11 for the 1951 medium treatment on sugar beets is included to indicate a representative comparison. When U_t was multiplied by a crop factor of 1.42, a cumulative curve nearly as good as $1.02E$ is obtained. If the crop K value in the Blaney-Criddle procedure is changed from the recommended value of 0.75 for sugar beets at Prosser to 0.88, the accuracy of the estimate is considerably increased, but estimates for July and August still fall quite short. A crop factor of 1.5 for late potatoes and 1.94 for early potatoes correlated U_t well with U. Corresponding best-fit crop factors, K, for U_b were 1.03 and 1.30.

As recognized by Criddle (11) a crop coefficient which would vary throughout the season could be applied to better correlate the Blaney-Criddle procedure with consumptive use. At this location, for example, the crop coefficient K, in

TABLE 1. CORRELATION BETWEEN U AND E, U_b AND U_t AND REGRESSION EQUATIONS FOR PERIODS OF GOOD CROP COVER

			U dependent on E		U dependent on U_b		U dependent on U_t	
Crop	Treatment	No. of pairs	Correlation coefficient	Regression equation	Correlation coefficient	Regression equation	Correlation coefficient	Regression equation
Sugar beets	Wet	33	0.86	$U = -.016 + 1.08E$	0.89	$U = -.177 + 2.44U_b$	0.88	$U = -.04 + 1.72U_t$
	Medium	25	0.94	$U = -.018 + 1.06E$	0.93	$U = -.177 + 2.42U_b$	0.92	$U = -.016 + 1.75U_t$
	Dry	20	0.93	$U = -.004 + 0.95E$	0.93	$U = -.133 + 2.04U_b$	0.92	$U = -.020 + 1.47U_t$
Late potatoes	Wet	43	0.75	$U = -.026 + 1.20E$	0.79	$U = -.197 + 2.64U_b$	0.77	$U = -.029 + 1.72U_t$
	Medium	25	0.85	$U = -.049 + 1.23E$	0.87	$U = -.246 + 2.82U_b$	0.88	$U = -.088 + 1.96U_t$
	Dry	14	0.82	$U = -.012 + 0.90E$	0.80	$U = -.148 + 2.03U_b$	0.83	$U = -.064 + 1.63U_t$
Early potatoes	Wet	42	0.79	$U = -.080 + 1.66E$	0.53	$U = -.359 + 3.95U_b$	0.44	$U = +.096 + 1.49U_t$
	Medium	30	0.78	$U = +.009 + 1.09E$	0.49	$U = -.091 + 2.22U_b$	0.48	$U = +.136 + 0.88U_t$

NOTE: All correlation coefficients are highly significant.

the equation $u=Ktp$, should vary from about 1.1 in July to 0.6 in September for the 1951 sugar beets.

Fig. 12 is a summary of the monthly totals of E, U_b, and U_t based on weather records for the month of July throughout the last 31 years as compiled by Nelson (12) and others. The July 1949, 1952, 1953, and 1954 values for consumptive use for alfalfa (extrapolated from measured periods of good crop cover) are also plotted. The changes in evaporation, E, from year to year are not similar to the changes in in U_b nor U_t in several instances. The curves indicate that other important factors influence evaporation besides those used in determining U_b and U_t. The limited consumptive-use information for alfalfa indicates trends similar to those for evaporation.

Statistical Evaluation

The rates of consumptive use which have been presented in all the graphs are mean values for treatments only. Table 1, however, presents the statistical results for the row crops during periods of good crop cover for all comparisons made between consumptive use and E, U_b, and U_t. Values of consumptive use were taken from individual plot measurements rather than treatment means and are based on soil samples taken from three locations per plot.

From Table 1 it is found that all correlation coefficients exceed the one per cent level of significance. Actually from a practical standpoint, some measurement would be preferable which would give an estimate equal to the consumptive use, or related to it by a constant ratio throughout the season. Expressed graphically it would be desirable to have a straight-line relationship between actual and estimated use which would pass through the origin.

Conclusions

By applying a constant factor for each crop, tank evaporation was adjusted to closely estimate actual consumptive use. For moisture treatments giving high yields in row crops, the adjusted cumulative evaporation remained within ¾ in of the actual measured consumptive use throughout the season of good crop cover. Consumptive use dropped off with drier moisture treatments, but the decrease was not large unless yields were materially lowered. The variation between U and adjusted E was slightly greater in alfalfa than row crops, probably because of the effect of cuttings. The favorable correlation between E modified by a crop constant and U indicates promise for development of evaporation equipment that a farmer could use to tell when to irrigate.

The Blaney-Criddle and Thornthwaite methods departed appreciably from measured consumptive use in this work. There is apparently some hazard in applying these procedures without checking to determine their applicability at a location, especially if they are to be used to schedule irrigation. A crop factor applied to the Thornthwaite procedure would have merit.

Tank evaporation, being influenced by many of the same factors which determine consumptive use, should be expected to be more effective in estimating water requirements than methods which depend on fewer of the climatic factors involved. The reported work, however, is only preliminary in nature and study is needed before recommendations for usage should be considered. Adapting a convenient tank usable to the farmers, establishing a proper tank environment, and relating evaporation to consumptive use by suitable crop factors are items needing study. From this work, however, it is believed that the direct use of evaporation data in estimating consumptive use and the application of them for scheduling of irrigation, offers considerable promise.

Summary

Rates of consumptive use of water by four crops grown at the Irrigation Experiment Station at Prosser, Wash., are presented. Rates of evaporation from a USDA, BPI evaporation tank, along with the estimated consumptive-use rates using the Blaney-Criddle and Thornthwaite procedures, are compared with measured consumptive-use rates.

During periods of good crop cover, tank-evaporation rates gave a much closer estimate of actual consumptive-use rates than either the Blaney-Criddle or Thornthwaite procedure. Although high correlation coefficients resulted from statistically comparing each of the three methods with consumptive use, it was found that for the Blaney-Criddle method the value for the crop coefficient should vary throughout the season. Estimates of consumptive use with the Thornthwaite procedure fell short of actual consumptive use, but by applying a constant crop factor, depending on the crop, they were adjusted to provide closer correlation.

Comparisons of the past 32 years' evaporation data during July with estimated consumptive use and with actual consumptive use for alfalfa during four of the last six years, indicates some problem in adjusting the Thornthwaite or the Blaney-Criddle procedure for this area, espeically for scheduling irrigation. The quite favorable results obtained with the evaporation pan show promise that this principle may be applicable in determining when to irrigate.

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Theoretical Aspects of Water Spreading

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WATER spreading on agricultural lands for purposes of recharging underground water reservoirs with excess winter surface flow has introduced a number of problems. Generally speaking agricultural soils are much less permeable than natural aquifer outcroppings. Furthermore, the permeability of the surface soil is greatly affected by many factors including working of the soil, natural and planted vegetation, amount and type of organic matter, changes in chemical and physical properties of the soil and the growth of microorganisms(1).* Considerable excellent research has been done by the Agricultural Research Service (USDA), the Kern County Land Company and the North Kern Water Storage District on the behavior of the soil surface under prolonged submergence and the reaction of infiltration rates to various surface soil-treatment programs in the spreading basins. This research is summarized in papers by Bliss and Johnson (2) and by Schiff (3) and is continuing. The purpose of the present paper is to discuss from a theoretical point of view some of the effects of variation in permeability of the soil with depth on the prolonged submergence infiltration rates. In addition, a method is proposed for the analysis of a prospective location for water spreading, including an evaluation of the degree to which benefits from surface treatments may be expected.

A theoretical approach to water spreading and infiltration does not imply a derivation of a set of exact equations from which proper design can be computed. Rather, from the application of principles of fluid mechanics to certain simplified or ideal systems, qualitative results may be obtained which may be used for design purposes from a "greater than" or a "less than" standpoint. More rarely, one may obtain quantitative results which may be used to establish the "equal to" criterion for design.

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*Numbers in parentheses refer to the appended bibliography.

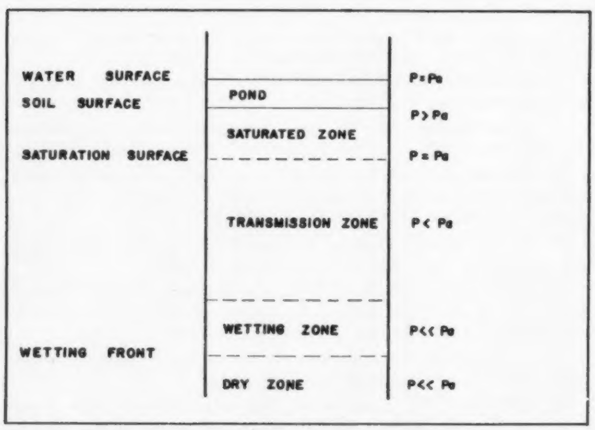

Fig. 1 Soil moisture zones during infiltration

Adequate design of a system for water spreading on agricultural lands requires a reasonable knowledge of the substrata and their permeabilities as well as the characteristics of the surface soil

MOISTURE ZONES DURING INFILTRATION

Laboratory experiments on one dimensional infiltration from a ponded water surface into a uniform soil column have been described by Bodman and Colman (4) and others (5). From these descriptions the soil water system can be subdivided into four more or less distinct zones as indicated in Fig. 1. Just below the ponded water surface is a very shallow zone in which the pressure in the liquid is at or above atmospheric pressure. In the subsequent discussion this zone will be referred to as the saturated zone. The lower boundary of this zone will be called the saturation surface and is defined as that surface in the soil where the pressure in the water phase is equal to atmospheric pressure and above which the pressure is greater than atmospheric pressure. The second zone may be termed the transmission zone. Water is transmitted through this zone at pressures less than atmospheric. The energy gradient over much of this region appears to be very close to unity. The third zone might be termed the wetting zone and is characterized by a rapidly decreasing moisture content with depth as contrasted with the transmission zone with nearly constant moisture content. The fourth zone consists of the portions of the soil which are not yet visibly affected by the infiltration. This zone may be termed the dry zone.

ONE-DIMENSIONAL INFILTRATION

One-dimensional infiltration may be analyzed by applying the Darcy equation to the flow in the saturated zone. Let the velocity be denoted by V and defined as the quantity of flow per unit time per unit area normal to the flow. The head at the lower limit of the saturation zone, i.e., the saturation surface, is zero by the definition of the saturation surface if the datum for elevation is taken on this surface. If the thickness of the saturated zone is z and the depth of water over the soil is d, the head on the upper boundary of the saturation surface is $d+z$ (Fig. 2). By the Darcy equa-

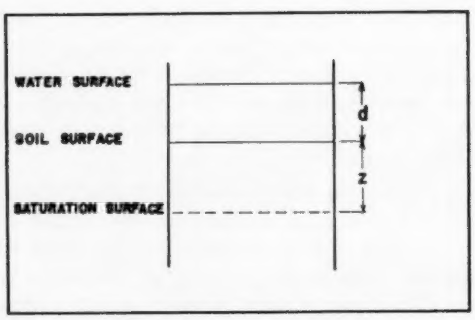

Fig. 2 Head loss in the saturated zone

tion, the velocity is equal to the permeability K multiplied by the head loss per unit distance.

$$V=K(d+z)/z \quad . \quad . \quad . \quad . \quad [1]$$

The infiltration rate is defined as the quantity of water per unit time per unit area which enters the soil surface. Thus for one dimensional flow the velocity determined by equation [1] is the infiltration rate. Equation [1] is the equation of a hyperbola with asymptotes $V=K$ and $z=O$. Therefore, as the saturation surface penetrates more deeply into the soil, the infiltration rate will decrease, approaching asymptotically a value equal to the permeability.

If the saturated permeability K_s remains constant throughout a soil of infinite depth, the penetration of the saturation surface for one-dimensional flow can be shown to be a continuously increasing function of time. Hence, even under ideal conditions of a stable soil and sterile system, the infiltration rate for one-dimensional flow may be expected to decrease with time. Equation [1] gives the rate of flow through the soil surface. Because of incompressibility, this is also the rate of flow past the saturation surface. Experimental data show that in at least part of the transmission zone the energy gradient is very nearly unity and the permeability is not greater than the saturated permeability. However, the gradient in the saturated zone is always greater than unity, hence more fluid flows into the top of the transmission zone than can flow through this zone. A positive difference between inflow and outflow rates indicates that fluid is accumulating in the intervening space. Ultimately this space will become saturated because of this difference.

An equation expressing this relationship may be written. Denote by Q the volume of water accumulating in this space per unit time. Then, for a cross sectional area A, a transmission zone permeability of K_t and a saturated zone permeability of K_s

$$Q=A[K_s(d+z)/z-K_t] \quad . \quad . \quad . \quad . \quad . \quad [2]$$

In the usual water-spreading problem the surface permeability K_s is far from constant but decreases with time due to colloidal swelling, microbial activity, etc. The effect on the penetration of the saturation surface can be noted from equation [2]. As K_s decreases for the reasons cited above, the term in the brackets will approach zero, reach zero and become negative. When it becomes zero the rate of accumulation is zero and the saturation surface will cease to advance. When the bracketed term becomes negative, the outflow from the transmission zone exceeds the surface inflow and the saturation surface will recede until the term is again zero. Because of this action, the saturation surface probably does not penetrate more than a small fraction of the pond depth on untreated soils.

INFILTRATION INTO STRATIFIED SOILS

Very few soils are uniform to any great depth. Those soils in many water-spreading areas have marked stratification. There are three major effects of stratification which will be treated in the subsequent paragraphs. The first effect is the creation of perched water tables above the less permeable strata. The second effect is the possible stabilization of saturation surfaces at the interfaces of less permeable layers above more permeable ones. The third effect is to change the effective permeability of a region containing several strata.

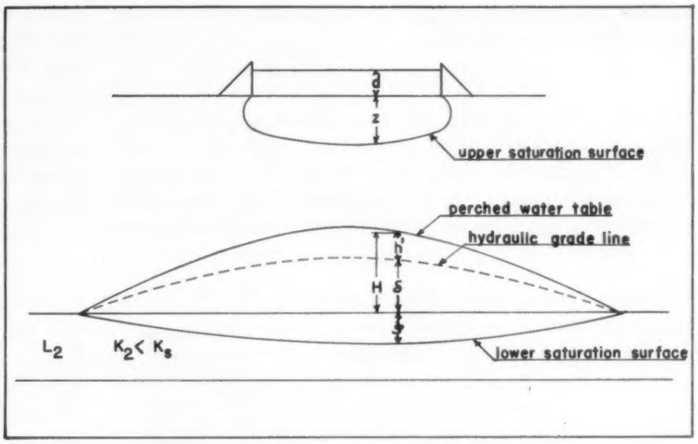

Fig. 3 Schematic diagram of a perched water table

Perched Water Tables

In most stratified soils there will exist one or more layers whose permeability is less than that of the overlying area. The rate at which such layers are able to transmit water is often less than the rate water reaches the layer from above. A perched water table results and continues to grow until the combined effects of increased area due to lateral flow and increased energy gradient are sufficient to transmit water through the less permeable layer as rapidly as it is received from above.

As shown in Fig. 3, the perched water table in many respects is a subsurface spreading pond with a depth of water δ corresponding to the positive pressure head at the top of the less permeable layer. If the layer of soil immediately below is not saturated, a saturated zone and saturation surface will develop within the less permeable layer. Let ζ represent the depth of penetration of the lower saturation surface, K_2 the permeability in the lower saturated zone and δ the head corresponding to the positive pressure at the top of the less permeable stratum. The velocity V_2 at which fluid will be transmitted through a point in the surface of this stratum is

$$V_2=K_2(\delta+\zeta)/\zeta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [3]$$

Stratigraphic Effects on Penetration of Saturation Surface

The saturation surface may be prevented from moving downward into the soil by the presence of a more permeable layer underlying a less permeable one. Equation [2] is applicable to this situation if K_s and K_t are replaced by K_1 and K_2, the permeabilities of the upper and lower layers, respectively:

$$Q=A[K_1(d+z)/z-K_2] \quad . \quad . \quad . \quad . \quad . \quad [4]$$

Applying the same reasoning developed in the previous section for variable surface permeability, the saturation surface will cease to penetrate deeper into the soil when the term in the brackets is zero. When the value of z is approximately equal to the depth z_1 to the bottom of the less permeable

stratum, the saturation surface cannot penetrate further if the ratio of K_1 to K_2 is such that

$$K_2/K_1=(d+z_1)/z_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad [5]$$

It follows from equation [5] that after moderate penetration, very little increase in permeability is required to stabilize the saturation surface until the saturated zone merges with a water table building from below. This latter action possibly accounts for some of the observed abrupt decreases in infiltration rate.

Effective Permeability of a Series of Strata in One-Dimensional Flow

The third effect of stratification is to render equation [1] for infiltration into uniformly permeable soils invalid. It may be replaced by an equivalent expression involving the concepts of effective permeability and effective length of flow path. For one-dimensional flow, the velocity through each successive layer in the saturated zone is a constant. For each layer (denoted by the index i)

$$V=\triangle h_i\ K_i/L_i \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad [6]$$

The total head loss through n such layers is

$$\triangle h=\sum_{i=1}^{n} V\ L_i/K_i \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad [7]$$

The terms of the sum can be reduced to a common denominator by the introduction of a reference permeability and an effective distance of flow.

$$(L_e)_i/K_e=L_i/K_i \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad [8]$$

The total head loss is thus equal to

$$\triangle h=V/K_e \sum_{i=1}^{n} (L_e)_i \quad . \quad . \quad . \quad . \quad . \quad . \qquad [9]$$

The rate of flow through the strata occupied by the saturation zone is, therefore,

$$V=K_e(d+z)/\Sigma(L_e)_i \quad . \quad . \quad . \quad . \quad . \quad . \qquad [10]$$

A similar equation may be written for vertical flow in perched water tables.

INFILTRATION WITH LATERAL FLOW

The downward flow under the central portions of very large spreading ponds is essentially one dimensional. Flow under small ponds will in general have both horizontal and vertical components. The simplified one-dimensional equations are no longer valid and must be replaced. The Darcy equation in its most general form remains valid, but its application is considerably less straightforward. However, it is possible to discuss some of the effects of lateral flow on infiltration rates and spreading pond design by the use of simplified equations.

Effect of Lateral Flow on the Saturated Zone

Capillary forces on the edges of the saturated zone produce a component in the hydraulic gradient in the horizontal direction. The resulting lateral flow creates a system of streamlines which diverge in the direction of flow. As they diverge within the saturated zone, the equation of continuity requires that the magnitude of the velocity decrease. At the same time, the minimum hydraulic gradient in the vertical direction is unity provided the saturated zone has not merged with a water table. Thus there is a minimum vertical component of the velocity which, by application of the Darcy equation, is equal to the permeability. Therefore, there must be a maximum permissible divergence of streamlines within the saturated zone. Consider a single expanding stream tube whose cross-sectional area at the surface is A_s and at a point p within the saturated zone is A_p. By the equation of continuity

$$V_p=V_s\ A_s/A_p \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad [11]$$

A vector is always equal to or greater than one of its cartesian components. Therefore, the least value of V_p obtainable will be equal to or greater than its vertical component. The vertical component is in turn greater than the permeability in the saturated zone. Thus for a point p in the saturated zone,

$$V_p\leqq K_s \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad [12]$$

By combining equations 11 and 12, the maximum possible cross-sectional area at a point p within the saturated zone is:

$$A_p\leqq V_s\ A_s/K_s \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad [13]$$

The streamlines, therefore, cannot diverge to an area greater than that given by equation [13], except by a decrease in K_s along the stream tube. This can occur in a uniform soil only by a decrease in moisture pressure to a value below atmospheric. Equation [13] thus also defines the maximum penetration of the saturation surface if the streamline pattern can be estimated for the saturated zone, e.g., by the use of flow nets. The effect of lateral flow is thus seen to result in prolonging the higher infiltration rates by limiting penetration of the saturation surface. Let L be the length of a stream tube in the saturated zone. Then with the point p on the stabilized saturation surface at a depth z below the soil surface, the velocity of infiltration is approximately

$$V_s=K_s(d+z)/L \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad [14]$$

Substituting equation [14] into [13],

$$A_p/A_s\leqq(d+z)/L \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad [15]$$

Since L is usually of the same order of magnitude as $(d+z)$, little divergence of streamlines will occur before the saturation surface is reached. Equation [15] would also indicate that small ponds will be much more responsive to surface treatment and to variations in depth of the water in the pond. This conclusion appears to be substantiated by experimental data of the USDA Agricultural Research Service and the North Kern Water Storage District.

Lateral Flow in Perched Water Tables

As water accumulates locally above a less permeable layer, energy gradients are established in the horizontal direction as well as in the vertical direction. Under these gradients lateral flow will occur, increasing the area of perched water zone. The accumulation is a complex unsteady flow problem, and the shape of the water table at any time is unknown. Under prolonged infiltration it is possible that an equilibrium will be reached during a spreading season. For this condition estimates of the possible area of the perched water zone may be made.

Equation [3] previously presented is an expression for the velocity at a point through a stratum supporting a perched water table. The total quantity of flow can be obtained by integrating this velocity over the area A_2 covered

by the perched water table. Thus the total rate of outflow Q_2 from the perched water table at any time is

$$Q_2 = \int_{A_2} K_2(\delta+\zeta)/\zeta \quad . \quad . \quad . \quad . \quad . \quad . \quad [16]$$

Referring to Fig. 3, δ is equal to the depth H of the perched water zone less the head loss resulting from flow between the top and bottom of the perched water zone. As an approximation, this head loss is equal to that which would occur if the velocity V_2 were the only velocity through the perched water zone. That is,

$$b' = K_1\, H/V_2 \text{ (approximately)} \quad . \quad . \quad . \quad [17]$$

The rate of inflow through the soil surface is also obtained by integration of the velocity through the surface over the area of the spreading pond.

$$Q_s = \int_{A_s} K_s(d+z)/L \quad . \quad . \quad . \quad . \quad . \quad . \quad [18]$$

The maximum growth of the perched water zone will have occurred when the total outflow from the perched water table is equal to the total inflow from the surface:

$$\int_{A_s} K_s(d+z)/L = \int_{A_2} K_2(\delta+\zeta)/\zeta \quad . \quad . \quad . \quad [19]$$

Equation [19] cannot be integrated directly, but the integrals may be eliminated by replacing the terms representing the hydraulic gradients by their average values with respect to the corresponding area. Denoting the averages by a bar over the quantity, equation [19] becomes

$$K_s\, A_s\, \overline{[(d+z)/L]} = K_2\, A_2\, \overline{[(\delta+\zeta)/\zeta]} \quad . \quad [20]$$

The average gradient at the surface can be determined from an estimated total infiltration rate for the area. The average gradient below the perched water table cannot be so estimated since the area A_2 is unknown. However, a range of possible variation of the average gradient can be determined, thus giving an "at least" and an "at most" value for the amount of lateral spreading at a perched water table. This value is important for the design of water-spreading basins for it indicates what, if any, spacing of successive ponds will give a minimum of interference between basins.

The "at most" value of A_2 corresponds to the minimum possible average hydraulic gradient through the less permeable zone which has created the perched water table. The minimum value is unity in this "lower saturated zone" (Fig. 3). Thus the "at most" value for A_2 is given by substituting an average gradient of unity in the right side of equation [20].

$$A_2(\text{at most}) = A_s\, [(d+z)/L]\, K_s/K_2 \quad . \quad . \quad [21]$$

The "at least" value for A_2 is of course equal to A_s. Under equilibrium conditions, equal inflow and outflow rates from the perched water zone may under some circumstances give an "at least" value for A_2 which is greater than A_s, thus further limiting the range of variation. The largest hydraulic gradient which can exist in the less permeable layer will determine the "at least" value for A_2 provided that the "at least" value so determined is greater than the area A_s of the pond at the soil surface. Since most microorganisms will be filtered near the soil surface, decreases in permeability due to this cause can be expected to be a minimum. Furthermore, if the site is at all suitable for water spreading, the less permeable layer should be relatively thin. Let it be presumed, as a first approximation, that the saturation surface at equilibrium has reached the bottom of the less permeable layer. Let the thickness of this layer be L_2. Equation 20 becomes

$$K_s\, A_s\, [(d+z)/L] = K_2\, A_2(\delta+L_2)/L_2 \quad . \quad [22]$$

The largest hydraulic gradient is seen to be obtained for the maximum value of δ, the average head on the top of the less permeable layer. In addition, from Fig. 3

$$\delta = (H-b') \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [23]$$

The maximum value of δ is obtained with a maximum value of H. In turn H is restricted only by the distance from the upper saturation surface to the less permeable zone. (Note that if H is greater than this distance, the upper saturated zone and the perched water zone merge thus affecting adversely the surface infiltration rate.) The "at least" value for A_2 is therefore

$$A_2(\text{at least}) = A_s[(d+z)/L][L_2/z_2 - b' + L_2)]K_s/K_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [24]$$

where z_2 is the distance between the upper saturation surface and the less permeable layer creating the perched water table. If equation [24] yields a value less than A_s, the "at least" A_2 is equal to A_s.

Equations [21] and [24] determine the range of variation of lateral flow in perched water tables. If equilibrium between inflow and outflow is not reached during the spreading season, smaller amounts of lateral flow should be expected. The approximate value of A_2 for design purposes can be estimated fairly accurately by these equations.

Conclusions

Equations [1] and [2] demonstrate that infiltration rates will decrease with time for uniform, stable, sterile soil-water systems. Equation [5] demonstrates that only small changes in permeability are necessary to stabilize the saturation surface at a point near the soil surface thus eliminating the decrease in permeability with time predicted for uniformly permeable soils. Lateral flow is also shown by equation [15] to limit penetration of the saturation surface thus prolonging high infiltration rates under small ponds. Small ponds should thus be expected to respond much more favorably to surface treatment and increases in pond depth. Finally a range of variation in lateral flow in a perched water table is given by equations [21] and [24]. It may also be noted by inspection that certain field conditions favor validity of one or the other of these equations. For example, under extremely large spreading ponds, the mean hydraulic gradient through the less permeable layer will tend nearer to the maximum. In such a case efficient use can be made of the vertical distance z_2 (equation [24]) to supply the necessary gradient to put a large quantity of water through the less permeable layer. If, in addition, z_2 is rather large (i.e., a deep-lying less permeable layer), considerable benefit can be expected from the use of large spreading ponds and equation [24] will be somewhat more accurate for computing lateral spread. On the other hand, if z_2 is small (i.e., a shallow-lying less permeable layer), there is less benefit to be derived from large ponds. Small ponds, as proposed by Schiff(6), whose spacing will be more closely dictated by equation [21], may be more suitable. *(Continued on page 399)*

Ammonia Loss from Sprinkler Jets

D. W. Henderson, W. C. Bianchi and L. D. Doneen

Investigation shows that the nearer neutral the pH of the fertilizer solution is kept, the greater the probability that all losses will be reduced to a minimum

APPLICATION of soluble fertilizers through sprinkler systems is of considerable interest because of the possibility of reducing costs by eliminating special operations for fertilizer application. However, it is well known that ammonia is a volatile substance, and that its escape from a solution to the atmosphere may occur in varying degree. Because of this fact farmers have been warned not to attempt application of anhydrous or aqua ammonia through sprinkler systems. It has not been so universally understood, however, that any solution which contains ammonium ions (NH_4^+) also contains free ammonia (NH_3) which is subject to loss through volatilization. The aim of the investigation reported here was to determine the magnitude of possible losses of common ammoniacal fertilizers. Some of the factors affecting these losses were studied so that recommendations could be made for reducing them to a minimum.

Experimental Procedure

The various solutions studied were made up with tap water in a 100-gal galvanized iron tank and pumped from the tank through a small, slow-revolving part-circle-type sprinkler set to distribute water through an arc of about 25 deg. Sixteen glass catch vessels approximately 6 in in diameter were placed at intervals of 2 ft along the axis of the pie-shaped area covered by the sprinkler. A few grams of boric acid powder were placed in each catch vessel to prevent loss of ammonia from the vessel during the run, which was of 25 to 30 min duration, and during subsequent handling.

Shortly after the beginning of each run, a sample of the solution passing through the sprinkler nozzle was taken. The temperature and pH of the solution were determined immediately, and the ammonia concentration measured by distillation and titration. The solutions in the catch vessels were composited for ammonia determinations. Losses of ammonia were computed from differences in concentrations of samples taken from the sprinkler nozzle and concentrations of ammonia in the catch vessels. These observed losses were corrected for water loss by evaporation. Correction was accomplished by determining the increase in chloride concentration from the nozzle to the catch vessels. Since the chloride content of the irrigation water used was low, enough sodium chloride was added to bring the total chloride up to 150 ppm. This chloride concentration is convenient for analysis, but is not sufficient to lower the vapor pressure of the water appreciably.

Since losses from the catch vessels were prevented by addition of boric acid, the values reported are limited to volatilization from the jet. Field application would result in greater losses since interception of water by crop foliage would allow more time for ammonia escape. Furthermore, losses from small droplets which drift out of the catch area would probably be greater because they are in the air for longer periods than that retained in the catch vessels. Losses from soil were not considered in this study since they presumably are small as long as the soil remains moist and are probably similar in magnitude to those incurred in broadcast methods of fertilizer application.

A few tests were made with an operating pressure of 60 psi at the sprinkler, but in most instances the pressure was 40 psi. Tests were carried out at both these operating pressures using the same fertilizer solution, and it was concluded

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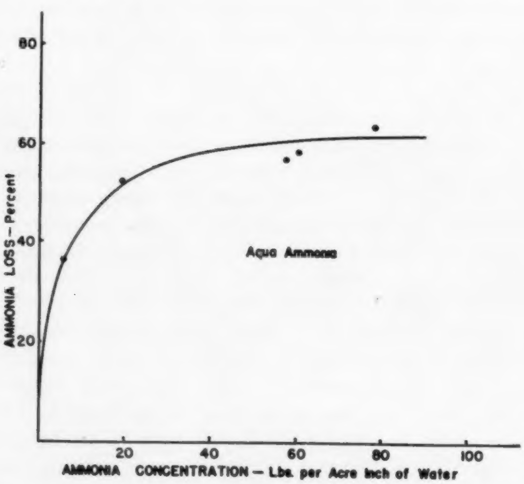

Fig. 1 Losses of aqua ammonia in relation to concentration of ammonia in the irrigation water

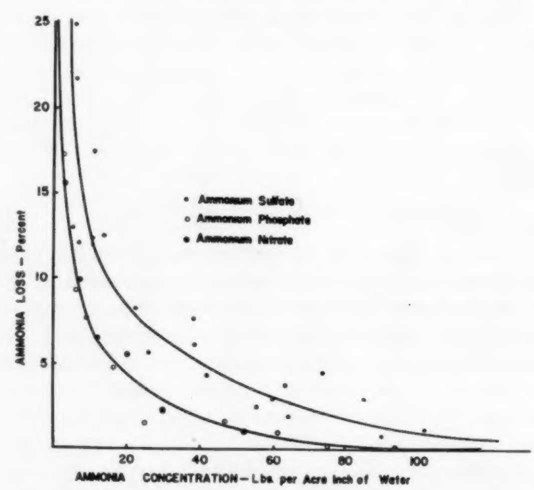

Fig. 2 Losses of ammonia from fertilizer salts in relation to ammonia concentration in the irrigation water

that the effect of operating pressure was small under the conditions of these trials.

Wind velocity, air temperature, and relative humidity were recorded for each test. Although no special attempt was made to study the effect of these climatic conditions on ammonia losses, it was observed that variations in duplicate determinations made under different weather conditions bore no consistent relationship to changes in the weather.

Solutions were made up from commercial fertilizers except for aqua ammonia for which ammonium hydroxide was used.

Results and Discussion

Losses of ammonia from aqua ammonia, ammonium sulfate, ammonium nitrate, and monoammonium phosphate were studied in relation to the initial concentration of the fertilizer solution. The results with losses expressed as percent of the initial concentration (pounds of ammonia per acre-inch of water) are given in Figs. 1 and 2.

As would be expected, losses from aqua ammonia solutions were very high, and increased with initial concentration. Losses from solutions of ammonium salts were appreciable at low initial concentrations, but decreased rapidly as the initial concentration was increased. Losses from ammonium nitrate and phosphate were essentially the same at equal ammonia concentrations and are represented by a single curve in Fig. 3. Losses from ammonium sulfate were appreciably higher.

Differences in the pH of the solutions after addition of the fertilizer materials accounts for much of the effect of initial concentration on ammonia losses. The tap water used to make up the solutions had a pH of 8.3. Addition of aqua ammonia increased the pH, but addition of the fertilizer salts studied decreased the pH through hydrolysis and the action of acidic materials remaining in the fertilizer salts from the manufacturing process. The observed losses of ammonia are shown in Fig. 3 in relation to the pH of the fertilizer solution. These data indicate that, if ammonia losses from sprinkler jet are to be kept below 10 percent, the pH of the fertilizer solution should be 8.0 or less; approximately 5 percent loss can be expected at pH 7.5, and loss is negligible if the pH is 7.0 or below.

Many factors will affect the pH resulting from addition of fertilizer salts to a given irrigation water. The most important of these are the pH of the water, buffer capacity of the water (particularly $CO_3^{=} + HCO_3^{-}$ content), the acidity of the fertilizer salt, and the amount of fertilizer added to the water. Since irrigation waters vary in pH and buffer capacity and fertilizer salts vary in acid content, the simplest procedure for controlling losses would be to determine the pH of the irrigation water after the addition of fertilizer materials. The use of commercial indicators in the form of paper strips would make possible rapid field checks.

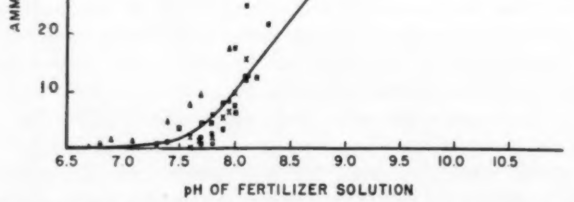

Fig. 3 Losses of ammonia from aqua ammonia and ammonium salts in relation to the pH of the fertilizer solution

More general recommendations can be made. If the irrigation water is essentially neutral (pH less than 7.5), addition of any acidic ammonium salt in appreciable quantity will reduce the pH to the extent that losses would be negligible. If the water has a pH of much above 7.5, losses can be reduced to a minimum by applying the fertilizer in the smallest possible amount of water which will not result in injury to the crop or sprinkler system.

The temperature of the irrigation water would presumably affect ammonia losses. A series of tests carried out with the same fertilizer solution (ammonium sulfate, 14 lb per acre-inch) at temperatures of 68, 77, and 90 F gave observed losses of 5.2, 6.6, and 7.6 percent, respectively. Losses may therefore be expected to increase as the water temperature increases. The water temperature for all other tests reported was approximately constant at 79 F.

Summary

Some of the factors affecting losses of ammoniacal fertilizers from sprinkler jets were investigated. The principal consideration is the pH of the fertilizer solution, which depends on characteristics of both the irrigation water and the fertilizer materials.

It should be emphasized that field application of ammonia fertilizers results in losses other than those from the jet. If the pH of the fertilizer solution being applied is kept as near neutral as practicable, it is probable that all losses would be reduced to a minimum.

Water Spreading

(Continued from page 397)

It is apparent that an adequately designed spreading system requires a reasonable knowledge of the substrata and their permeabilities as well as the characteristics of the surface soil. In this respect, a small pipe jetting rig such as described by Reger et al(7) should prove to be a valuable supplement to well logs taken in the vicinity of a proposed spreading site.

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Tile Drainage of Sloping Fields

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A study of the effect of tile direction on drainage capacity in sloping fields

IN SLOPING fields, a tile line or a system of equidistant tile lines (laterals connected by a main) can be installed at different directions with respect to the contour lines. They can run parallel (transverse drainage), perpendicular (longitudinal drainage) or at some angle between 0 and 90 deg (oblique drainage) with the contours.

In the literature, numerous examples are given of heterogeneities in the soil (outcrops of pervious or impervious layers, old streambeds in constructional landforms, etc.), together with recommendations as to how to drain the local wet areas caused by these heterogeneities. It is often difficult in those cases to determine which situation occurs in a particular field. Once it has been determined, however, the drainage then is generally obvious. Furthermore, it is generally agreed that tile for intercepting foreign water should be installed parallel with the contours. In the case of uniform isotropic soils, however, where a uniform excess moisture calls for a systematic drainage system, contradictory recommendations and arguments with respect to the proper direction of the laterals have been presented.

The question of longitudinal versus transverse drainage has been approached from different points of view. Most authors agree that the chance of sedimentation in the mains is less in the transverse systems, the mains having steeper slopes than the laterals. Transverse systems, however, may be hard to install if the slopes of the laterals become too flat. It has furthermore been argued that transverse systems are to be preferred from a standpoint of surface runoff (27)*. Recommendations for maximum and minimum tile grades may lead to the adoption of either system, depending on the slope of the field.

The most controversial aspect has been the rate of groundwater movement into identical longitudinal and transverse systems in uniform soils. Vincent (32) and others stated that, with transverse lines, part of the water seeps back into the soil at the downhill side of the tile after it has entered it at the uphill side. Next, Merl (19) and Gerhardt (14) claimed that transverse systems have a greater draining capacity. Gerhardt later abandoned this view (27), but the same argument, although explained in a different way, has been presented in the British literature (16, 20). The recent German literature (23, 25, 26) still recommends transverse systems.

Chronologically, before 1890 it was generally agreed that the longitudinal system was best (11, 18, 32, 34), possibly as a result of existing practices with stone drains. The sensitivity of stone drains to sedimentation and their high hydraulic resistance made installation with the steepest possible gradient necessary. After 1890, transverse systems were recommended in the European literature on the grounds of their supposedly greater draining capacity or "better" operation (9, 13, 14, 19, 20, 23, 25, 26, 31). The American literature (2, 8, 21, 22, 28) with a few exceptions (10, 12) remained in favor of the longitudinal system. In some of the most recent American drainage literature (1, 24) the problem of transverse or longitudinal drainage as such is not mentioned any more. Instead, recommendations are given for maximum and minimum tile grades.

Although the arguments used by several authors to demonstrate the greater draining capacity of one or the other system are subject to severe objections, it was felt that the difference between ground-water flow patterns of the two systems could result in a difference in draining capacity. For this reason the study was initiated.

Approach to the Problem

In the course of this investigation, distinction has been made between two cases. In the first case, the phreatic surface coincided over the entire field with the surface of the ground (surface runoff impending or already developed). The boundary conditions in this case were fixed and identical, whether the drainage system was longitudinal or transverse. In the second case, the soil was not saturated to the surface and the phreatic surface could seek its own shape. The shape of the phreatic surface in a transversely drained field differed from that in a longitudinally drained field.

Since capillary action was absent in the first case, this case was suited to a model study. The second case was approached mathematically. Field studies were not considered feasible because of difficulty of controlling the many variables, and the high cost involved .

The Model Study

The model consisted of a heavy wooden box, 5 ft square and 18 in deep. Drains were constructed from 80-mesh stainless steel wire cloth. A fine uniform sand formed the porous medium. The scale of the model was 1:30 and field spacings of 36 ft, 72 ft and 144 ft at a field tile depth of 3 ft could be represented. Keeping the depth of the drains in the model constant, the distance of the bottom of the box (i.e., impermeable layer) below the drains could be varied. The model could be tilted by various degrees in a direction normal to the drains (transverse drainage) and parallel with the drains (longitudinal drainage). A thin sheet of water running continuously over the surface was used to approach a phreatic surface coinciding with the ground surface. The sand was protected from erosion by three layers of cheese cloth underlying a stainless steel screen.

Inasmuch as the walls of the model normal to the direction in which the box was tilted did not coincide with natural stream surfaces, the flow pattern was disturbed, especially in the case of longitudinal drainage. To minimize the influence of this disturbance on the results, the drains

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*Numbers in parentheses refer to the appended bibliography.

were divided into three sections and the discharges only measured from the middle section.

Results of Model Studies

The results obtained from the model study were expressed as the ratio of the drainage capacity of the transverse system to the drainage capacity of the corresponding longitudinal system, symbolized by *Rtl*.

Values of *Rtl* were determined at slopes of 5, 10 and 15 percent for different drain spacings and depths of the impermeable layer. *Rtl* appeared to scatter around 1.00 with values between 0.96 and 1.03. No relation existed between *Rtl* and the factors that control the flow conditions (depth and spacings of drains, depth of impervious layer, and field slope).

Computations showed that a consistent decrease in *Rtl* of about 1 percent for each increase of slope of 5 percent was introduced by the fact that the longitudinal drains had about the same slope as the tilt of the box, while the transverse lines kept nearly the same slope with which they were installed regardless of the tilt of the box. Thus the flow depth in the drains was less in the longitudinal systems, particularly at the greater slopes.

Since the surface of the sand could not be made perfectly flat, the thickness of the runoff sheet at a particular location may have varied with the direction in which the model was tilted, thus influencing *Rtl*.

The depths of the impervious layer below the drains included in the tests ranged from zero to one-fifth of the drain spacing. With regard to influence on drainage, the latter depth of the impervious layer can be considered as being infinite (15, 29).

Calculation of Rtl

In tile-drained sloping fields a ground-water particle moves under the combined influence of the tile and of the slope of the water table as introduced by the slope of the field. Moreover, the velocity potential due to tile lies in a direction normal to the tile, whereas the velocity potential due to slope lies in a direction normal to the contours.

Since, in a longitudinal system, the tile lines also run normal to the contours, the velocity potential due to the slope is normal to the velocity potential due to the tile. When the resultant of these potentials is resolved into components, that component normal to the tile, which controls the flow of water into the tile, is identical to the velocity potential due to tile. In other words, slope does not affect the draining capacity of longitudinal systems, or longitudinal systems have the same draining capacity as identical systems in horizontal fields under otherwise the same conditions. The same thought is underlying Waring's recommendation of longitudinal systems (34), although not so stated specifically. This characteristic, which also appears from the results of the model study, reduces the comparison between longitudinal and transverse systems to that between horizontal and transverse systems. (With horizontal systems are meant drainage systems in horizontal fields.)

Tile-drainage systems in horizontal fields with uniform soils can be characterized by the following dimensionless quantities (given a certain tile diameter): x/m, d/m and k/s (Fig. 1), where

- x=one-half of the tile spacing
- m=vertical distance of water table at middistance between the tiles above the tile
- d=distance of the impervious layer below the tile
- k=permeability of the soil (dimension length/time)
- s=drainage coefficient (dimension length/time)

The quantities x/m and d/m describe the geometry of the system, whereas k/s represents the reciprocal of the drainage coefficient at unit permeability. Nomographs constructed by relaxation processes relate k/s to x/m and d/m (33). If the impervious layer is at great depth, x/m is the only controlling factor of k/s. Consequently deep drains with wide spacings and shallow drains with narrow spacings have the same draining capacity as long as their x/m values are the same.

Fig. 2 shows a cross section of a transversely drained sloping field, with uniform infiltration (arrows equally spaced). The uniformity of infiltration causes the water table to attain such a shape and elevation that at steady conditions

$$\frac{x_1}{m_1}=\frac{x_2}{m_2} \qquad [1]$$

In other words, a transverse tile line acts at its uphill side as a deep, widely spaced drain and at its downhill side as a

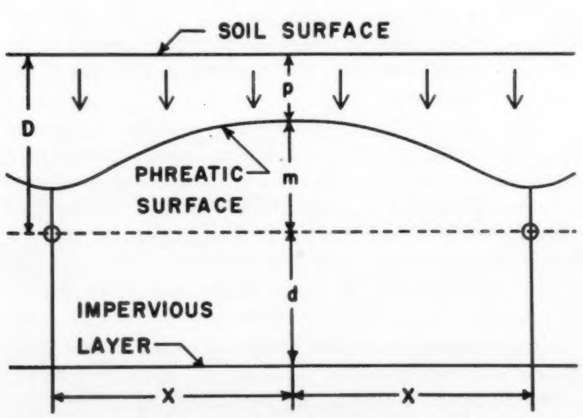

Fig. 1 Flow system in a tile-drained horizontal field

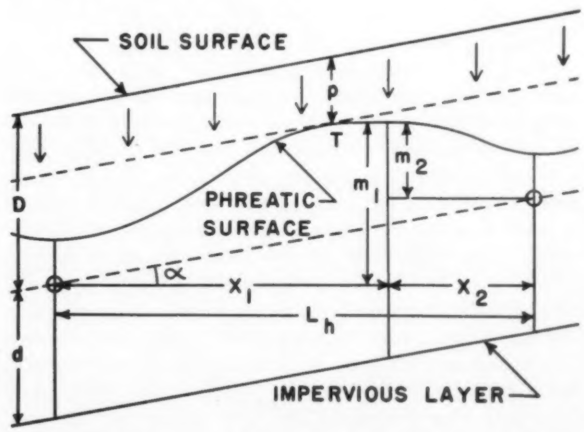

Fig. 2 Flow system in a transversely drained sloping field

shallow, narrowly spaced drain. The k/s values corresponding to the x/m values of the system can be found with the nomographs (33). From Fig. 2 appears

$$m_1 = m_2 + L_h \tan \alpha \quad . \quad . \quad . \quad . \quad . \quad . \quad [2]$$

and

$$L_h = x_1 + x_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad [3]$$

From equations [1], [2] and [3], the following expression for L_h can be derived

$$L_h = x_2 \frac{2}{1 - \frac{x_2}{m_2} \tan \alpha} \quad . \quad . \quad . \quad . \quad . \quad . \quad [4]$$

The next step is to evaluate the drain depth D for the transverse system.

The minimum permissible distance p of the water table below soil surface (Figs. 1 and 2), together with the drainage coefficient s of the system at the position of the water table characterized by p, constitute the drainage criterion on which the design of a drainage system should be based (15). On the other hand, it is possible to characterize existing drainage systems by their draining capacity at the position of the water table characterized by p. For horizontal systems, p is found at middistance between the tiles (Fig. 1) and the tile depth D is found by adding m to p. In the case of transverse systems, however, p is found at point T where a line having the same slope as the field is tangent to the phreatic surface (Fig. 2). To determine the location of point T, it is necessary to know the shape of the phreatic surface. Inasmuch as it has not been possible to develop simple equations that describe phreatic surface shapes, the tile depth for transverse systems was determined graphically. For this purpose a set of water table shapes with different x/m values was obtained by interpolation from theoretical curves presented by Childs (4, 5), Kirkham and Gaskell (17) and Van Deemter (29). A similar set was constructed from empirical curves presented by Spottle *et al.* (27), Debauve (7) and Van Schilfgaarde (30). Finally k/s values were evaluated from the nomographs for horizontal systems with the same tile depths and spacings as were found for the transverse systems, and *Rtl* computed.

TABLE 1. RESULTS OF THE CALCULATIONS OF Rtl FOR FREE BOUNDARY DEVELOPMENT.

transverse systems		Rtl	
slope in %	$\frac{x}{m}$	theoretical curves	empirical curves
5	2.50	1.00	0.90
10	2.50	0.90	0.90
15	2.50	0.80	0.90
5	3.75	1.02	1.00
10	3.75	1.02	1.02
15	3.75	1.07	1.07
5	5.00	0.96	1.00
10	5.00	0.99	1.01
15	5.00	1.03	1.05
5	6.00	0.98	0.97
10	6.00	1.04	0.98
15	6.00	1.11	1.06
5	7.00	0.98	1.01
10	7.00	1.00	1.07
5	8.00	0.96	0.97
10	8.00	1.05	1.10
5	9.00	0.94	0.99
10	9.00	1.08	1.14
5	10.00	0.93	1.11
5	12.50	1.02	1.05
5	15.00	1.04	1.08
5	17.50	1.02	1.02

Summarizing, the calculation of *Rtl* for free boundary development consists of the following steps:

1 Starting with transverse systems, assume a range of values for x/m.

2 Using the nomographs, find the k/s values corresponding to the assumed x/m values.

3 Calculate L_h for the transverse system with equation [4] for the assumed x/m values at different field slopes. Computations are facilitated by assigning a concrete value to m_2, thus giving the system a certain scale.

4 Using both theoretical and empirical shapes of phreatic surfaces, evaluate D for a given value of p.

5 Using the same value of p, find k/s for horizontal systems having the same depths and spacings as found for the transverse systems.

6 Calculate *Rtl* as

$$Rtl = \frac{(k/s) \text{ horizontal}}{(k/s) \text{ transverse}}$$

The results of these computations show that the values of *Rtl* are scattered around 1.00 (Table 1) with no relation to x/m and a slight tendency to increase with increasing slope.

Discussion of Results

Theoretically, the nature of the problem should not permit *Rtl* to scatter around a certain value. There is either a clear relation between *Rtl* and the factors that determine the geometry of the system or there is no relation at all.

Two quantities should have an undisputed influence on the deviation of *Rtl* from one if this deviation were to exist: the slope of the field and the spacing of the drains. The slope of the field may be considered as being responsible for the existence of the two different drainage systems. If the slope of the field were zero, there would be no question of direction of tiles with respect to contours because there would be no contours. Consequently, any difference between longitudinal and transverse systems should clearly bear the influence of field slope. The influence of the tile spacing becomes clear in the case of a zero spacing. If the tile lines lie right next to each other, it does not make any difference what direction these lines have with respect to the contours. A difference may start to develop, however, if the lines are moved apart.

The depth of the impervious layer and the position of the water table characterized by m, merely control the type of flow (radial or uniform rectilinear) that dominates in a given system. The model studies indicated that both for small values of d with rectilinear flow dominating and for large values of d with radial flow dominating, *Rtl* was equal to one. Consequently, the depth of the impervious layer is not important as far as *Rtl* is concerned.

The graphical evaluation of the tile depth in transverse systems with free boundary development was very sensitive to small changes in degree and location of curvature of the phreatic surface. Since the shapes of the curves used in this

process may easily have been affected with some deviation from the true shapes, not too much value can be attached to the slight tendency of *Rtl* to increase with increasing slope.

Based on the scattering of *Rtl* around one and the absence of clear influences of the factors controlling the flow system, the conclusion is that both for fixed and free boundaries, no difference exists between the draining capacities of comparable longitudinal and transverse tile-drainage systems.

Summary and Conclusions

Transverse and longitudinal tile-drainage systems in uniform soils have been compared with regard to their draining capacities. In the drainage literature, different opinions about this subject are found, and contradictory recommendations for the proper direction of tile lines with respect to field contours have been made.

In the course of this investigation, distinction has been made between two cases. The first case, where the phreatic surface coincided over the entire field with the ground surface, was studied by means of a model. The second case, where the soil was not saturated to the surface and the flow system could seek its own phreatic surface, was approached mathematically.

The results showed that for both cases comparable longitudinal and transverse tile-drainage systems have the same draining capacities. On the basis of this result, it is recommended that tile lines (laterals) be installed at an angle between 10 and 30 deg with the contour lines. The lower limit of 10 deg is merely to indicate the practical undesirability of a tile parallel with the contours. The advantages of the recommended direction are:

- The main can be installed with a steeper grade than the laterals. This reduces sedimentation and allows a smaller diameter for the main.
- By letting the tiles diverge slightly from the contours the grades are sufficient that installation is not difficult.
- Although diverging somewhat from the contours, the laterals still have an effective direction with respect to surface runoff (27), to remnants of old streambeds, and to other natural drains (old stone drains).
- A reasonable divergence of the tile from the contours still takes advantage of a possible development of anisotropy in the soil with the greatest permeability in the downhill direction due to a repeated downhill movement of ground-water during the past (6). More research, however, is needed concerning this point.

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RESEARCH NOTES

Brief news notes and reports on research activities of special agricultural-engineering interest are invited for publication under this heading. These may include announcements of new projects, concise progress reports giving new and timely data, etc. Address: Editor, AGRICULTURAL ENGINEERING, St. Joseph, Michigan.

USDA Research Activities

Superior Service Awards. Three ASAE members, on the staff of USDA's Agricultural Engineering Research Branch, ARS, received USDA Superior Service Awards at the honor award ceremonies held June 1, at the Sylvan Theater, Washington Monument Grounds, Washington, D. C.

The awards, presented by Secretary of Agriculture Ezra Taft Benson, were made to Jordan H. Levin and Harold P. Gaston of the Mechanical Preparation and Conditioning Section, AERB, for their research efforts at Michigan State College, on means and methods of handling fruit, and to Elmer B. Hudspeth Jr., of the Farm Machinery Section, for his work in connection with cotton mechanization at Lubbock, Tex.

Silo Research Continued. Experimental horizontal silos, constructed last year by the Farm Buildings Section of the AERB at Agricultural Research Center, Beltsville, Md., have been refilled for further tests of silage quality, means of covering, filling operations and pressures. The work will also include feeding tests and pasture station studies making use of a portable electric fence, to be conducted later by the Dairy Research Branch of ARS.

One of the silos was filled with chopped forage and the other with long grass, making possible the testing of new forage harvesters and tractor-mounted buckrakes by engineers of the Farm Electrification Section and the Farm Machinery Section. New pressure panels installed recently by engineers of the Farm Buildings Section are expected to give more accurate results of silo pressure studies than those previously obtained.

Cattle Shelter Handbook. A new illustrated handbook, "Cattle Shelters and Equipment for Southern States" (No. 81) has been prepared and issued by AERB. The plans shown in the handbook are available to farmers in the southern region through state agricultural extension services.

Included in the handbook are sketches of pole barns of various types, cattle pens, chutes and handling equipment for the farm. These depict plans developed cooperatively by USDA and the state colleges in 13 southern states as a result of farm buildings research.

Working drawings listed in the publication may be obtained from county agents or from the extension agricultural engineer at state agricultural colleges in the southern region. They are not distributed by the U.S. Department of Agriculture.

Radiofrequency Treatments. Strawberry plants are being treated by radiofrequency by S. O. Nelson, Farm Electrification engineer stationed at the University of Nebraska, as a means of controlling the virus diseases that cause yellows and crinkle. Plants under test have survived the treatment, but it is still too early to determine effect of the treatment on the viruses.

The Farm Electrification Section reports some success in the dielectric treatment of small grain for smut. Good results were obtained under the first test as compared with the untreated check.

Annual Report of the Secretary for 1954-55

To the Council and Members of the American Society of Agricultural Engineers:

A forward look has been chosen as the theme of the Secretary's report this year. As a major objective, the report will attempt to evaluate past and present society activities as a basis for intelligent projection.

On the horizon there appears an increasingly bright future for our profession—a future of increased opportunity for engineering services to the agricultural industry. The number of production units in agriculture will likely continue to decrease with increased production per unit. At higher levels of output engineering applications become increasingly profitable.

Greater engineering emphasis will be given to the reduction of chore time and increased efficiency of operations in and near farm buildings. This will be concurrent with further advances in the mechanization of field operations. The agricultural engineer will attack with increased vigor such areas as fruit and berry harvesting; transplanting operations; increased use of electronics in grading operations and in the maintenance of product quality, animal, plant and product environmental studies; and the engineering implications associated with scores of other problems in all segments of agriculture.

It behooves the Society to point the way in these and all new agricultural engineering developments. Never should satisfaction be gained from simply being abreast of progress; ASAE should serve to inspire agricultural engineers to produce at their maximum rates and to make their greatest contributions to the progress of the profession. Our Society can be this source of stimulation only as individual members contribute to its progress and welfare through suggestions and active participation in its affairs.

To the extent this is achieved agricultural engineers will consider membership in the Society to be a basic necessity for their professional progress. Enthusiasm of members will prove contagious, resulting in the most effective solution to the problem of society growth.

Growth. Growth of the Society will, as in the past, continue in two directions. Great potential still exists in those areas now generally recognized as being parts of the agricultural engineering profession. Outside of the Society are many engineers providing a service to agriculture through farm equipment manufacturers and distributors, public utilities, state colleges and universities, agricultural and engineering experiment stations, agricultural extension services, and various units of the United States Department of Agriculture.

The Society can grow in a broadening direction by gaining the membership of those engaged in areas near the present boundaries of the agricultural engineering profession. For example, prospective members may be found among those engaged in such diverse fields as engineering appraisal, private practice, design and development of specialized equipment, production and/or processing of various agricultural commodities, farm management, land development, agricultural aviation, wholesale and retail sales, farm safety, contracting, publications, advertising and sanitation. Agencies, both public and private, having a primary interest in the modernization of agriculture are good sources of prospective members.

This second direction merits considerable thought and work toward a sound policy as to how far and how fast the ASAE can proceed and the manner and extent to which it can attempt to serve as an effective organizational mechanism for a wide diversity of technical and professional interests.

Growth should not, of course, be taken as the sole measure in determining the effectiveness of the Society in serving its members and the profession of agricultural engineering. It is nevertheless a very important indicator of the Society's vitality and vigor and the determination of its members to keep the Society an organization constantly pressing for a more effective engineering service to agriculture. Growth is an essential ingredient in any forward-looking organization.

Most, if not all, society members have heard of the slogan "5000 Members in '55" developed in conjunction with the drive for new members currently in progress. President Nutt emphasized the importance of the drive in his letter to the society membership dated May 10. With a view of reaching the goal of 5000 members in 1955, the Secretary's office is laying particular stress on increased membership. Contacts with agricultural engineering department heads, divisional and sectional officers along with as many additional personal contacts as possible have been fairly effective in progress to this time. As this is written (mid-May), the society membership numbers 4407, as compared with 4187 reported in the Secretary's report of last year. In addition 172 applicants are currently in the process of election to membership. Considering only members in good financial standing, the drive began approximately four and one-half months ago with a few less than 4200. The present membership plus those in process of election indicates a total gain since January 1 of 382 members. If the present rate of gain can be maintained, the goal of 5000 members on December 31 should be realized provided applicants in process of election to membership are considered in the total membership figure.

The new members gained and to be gained by the present membership drive will, of course, mean much to the Society. Of at least equal importance, however, is the hope that the present emphasis on membership will awaken in members a new sense of individual responsibility for the continued growth and effectiveness of their professional engineering society.

There are, of course, many problems associated with growth. For example, a forward look demands an answer to the question of how to make new members feel at home in the Society or, better perhaps, how to quickly and effectively incorporate their abilities into society affairs. Most of the members who resign or drop out do so after three to seven years of membership during which time they may have attended few, if any, sectional or national meetings. Their location or work may have given them few contacts with other agricultural engineers and little identification or recognition in their chosen professional field. In such contacts as they have had with the Society, they may have found no group or committee actively working along lines of their particular interests. Perhaps they have not felt well enough acquainted in the Society or familiar enough with the mechanics of its operation to try to find out which other members might have similar technical and professional interests, and to start some activity along those lines.

Educational institutions can be of great assistance in properly indoctrinating the

young engineer with his need for contacts and ingredients of professional progress normally supplied by his professional engineering society. Continuation of this indoctrination by aggressive employers would prove of great benefit. Yet despite the importance of these aids, the problem remains a real one in a forward-look at our Society and its work.

A further problem of growth is the fact that the Society has to lift itself by its own bootstraps financially. Desirable activities which would strengthen the Society can be placed in operation only as increased financial means become available, and this oftentimes centers about the necessity for increased membership.

Meetings and Organization. The future will undoubtedly hold major changes in the present make-up, organization and scheduling of our national meetings. Meetings of the technical divisions at widely separated geographical locations may well become part of the Society's meeting plan. Joint programs between divisions will have increasing appeal, particularly as the technology of our profession is brought to bear on the development of over-all production plans for agricultural units. Divisional and joint divisional programs sponsored by sectional organizations seem to be in the offing. Although it is only natural that considerable inertia and resistance to change have been built into the present generally satisfactory meeting schedule, it is not wise to consider it inflexible or unyielding to the interests and desires of large segments of the Society's membership.

A forward look at committee activities within the Society indicates that this type of work will continue and increase in importance. A greater emphasis will be placed on clarifying and pin pointing problems along with the development of procedures for their solution. Division committees will be increasingly controlled by well-organized steering committees who will insist that the committee's work be directed toward the accomplishment of clearly stated, reasonable objectives. Target dates for completion of the committee's assignment or specific parts of the assignment will be established. Divisional steering committees will be called upon to a greater extent to collaborate with the Secretary in suggesting to the President suitable individuals for committee appointments, in reviewing at least annually the status of the committee's work and in analyzing and taking appropriate action on committee reports.

This same line of reasoning should be applied to the divisional organizations. As technical emphasis shifts, based on technological progress, divisional organizations should reflect these changes. It is not outside the realm of possibility that the present divisions might at some future time see fit to merge, a single division divide, and other major changes take place toward making the organization of the Society better suited to serve the professional needs of its members.

Every indication points to the continued growth and effectiveness of our sectional organizations as one of the most important means of the Society carrying out its objectives. Few, if any, would dispute the fact that the service rendered by the sections has exceeded even the greatest hope of their organizers. They form a solid foundation on which to an increasing extent the hopes and aims and ambitions of the Society are based. Servicing and the encouragement of these sectional organizations will become an increasingly important function of the headquarters operation.

Student Recruitment. The Society will carry its share of responsibility in the work of the engineering profession to acquaint American youth with their responsibilities and opportunities to produce to the full limits of their ability in a free society. The Society will encourage accurate presentations of the opportunities and responsibilities of professional engineering as illustrated by the education and ability of the agricultural engineer. This activity of accurately presenting agricultural engineering as a vocation to qualified high school youth will command the interest of all organizational elements in the Society—headquarters, sections, divisions, and committees. Problems incident to student recruitment will be solved not by defeatist attitudes but through hard work, sound factual approaches, and in general by a program having greater appeal than those presented by professions and vocations with which agricultural engineering is in competition for prospective students. The present motion picture program is a splendid example of effort properly directed to achieve this goal.

The future holds greater team work between agricultural engineering departments and the Society in indoctrinating agricultural engineering students with a professional consciousness. Student branch organizations and the Student Member program will be of increasing concern to all elements of the Society.

Public Relations. In looking ahead one must appreciate the importance of the continued development of a sound public relations program. This must go considerably beyond effective coverage of our national and sectional meetings. Agricultural engineers in common with engineers in other branches must become more proficient in telling others of their work. Members of the Society wherever they may be located can be of great assistance in acquainting the Secretary with opportunities to make the profession better known. Channels are available for the dissemination of information if story opportunities are known and properly exploited. Through the interest of individual members or small groups of members the following projects, now under way, are valuable parts of the over-all public relations program now in operation in the Society:

1. Motion picture depicting the agricultural engineering profession which was the subject of a general mailing in April.
2. An article dealing with the Society and the development of the agricultural engineering profession is scheduled for publication in the July issue of the *General Electric Review*. This article is one of a series featuring the history and activities of professional engineering societies in the United States.
3. The Society has accepted an invitation to have a booth among the educational exhibits at the Centennial of Farm Mechanization to be held at Michigan State College in August. The exhibit will emphasize the professional stimulation which agricultural engineers receive from working together in their own professional engineering organization.
4. Information on the Society's activities in the field of standardization has been provided the National Industrial Conference Board as a contribution to a study it is making in cooperation with the Mellon Institute on the present significance and use of industrial standardization.
5. At the invitation of the Trade Association Division of the United States Department of Commerce, information on the Society has been supplied for inclusion in a section on professional engineering societies to be included in the new directory of trade associations being published by the Department.
6. At the invitation of the American Society of Mechanical Engineers the ASAE was officially represented at the organization anniversary meeting of that society held at the Stevens Institute of Technology, Hoboken, New Jersey, on April 16. President Nutt designated Mr. L. H. Skromme, senior vice-president of the Society, as the official ASAE representative. This meeting was part of the ASME diamond jubilee celebration. Official greetings were extended by Mr. Skromme from the current and first president of the American Society of Agricultural Engineers, Professor George B. Nutt and Dr. J. B. Davidson, respectively.
7. The Society had official representation at the golden anniversary meeting of the Society of Automotive Engineers held in Detroit, Michigan, on January 12.
8. The agricultural engineering profession will be appropriately covered in future yearbooks and revisions of the Encyclopedia Brittanica.

Suggestions are solicited from members relative to the continued expansion and increased effectiveness of the Society's public relations program.

To an increasing extent the Society will be active among those organizations having as a goal the over-all advancement of the engineering profession. Affiliation and cooperation with other professional and scientific groups will continue at an accelerated pace. The Council wisely recognizes this as essential to the continued effectiveness of the Society in serving the profession and its members.

The President. A very important part of the progress which the Society has made during the past year centers about the fine work of our President, Professor George B. Nutt. His actions have not only been well considered and wise but his leadership aggressive and dynamic. His duties as president have been discharged in a manner as to bring credit not only to himself but to the Society and agricultural engineers everywhere.

Headquarters. The forward look materialized in the matter of headquarters location between the time this report was started and its completion. Moving day came at a time when arrangements for the annual meeting had peaked the headquarters work load, but the action was necessary if advantage was to be taken of a more favorable location for our operation. The headquarters now occupies the first floor of the Masonic Temple, 420 Main Street, in St. Joseph. Main Street at our location forms highway routes US 12 and 31. You are cordially invited to visit us whenever you pass this way.

The headquarters staff consists of nine full-time and two part-time employees. As evidenced in the recent move, the staff has the splendid ability to act as a unit in the interests of the Society. During the coming year it is hoped that many of the routine headquarters functions can be studied, streamlined, and incorporated into a standard operating procedure. A forward look includes more complete up-to-date and

meaningful membership records, a policy guide for councilors, a guidance manual for student branches and Student Members, a study of past, present, and potential services of ASAE members in the national defense, expansion of the Personnel Service—these are but a few of our aims and ambitions.

Those of us at headquarters feel a genuine concern for your professional development and welfare. Only through the maximum development of its individual members can our Society grow and render its greatest service to the advancement of the agricultural engineering profession.

Respectfully submitted,

FRANK B. LANHAM, *Secretary*

June 14, 1955

Annual Report of the Publisher for 1954-55

To the Council and Members of the American Society of Agricultural Engineers:

A primary object of the Society, as stated in its Constitution, is "to promote the science and art of engineering in agriculture." One means to this end is the publication of the body of information that is considered an essential tool of the members in their work as agricultural engineers.

The American Society of Agricultural Engineers in common with other technical societies early found it necessary to provide its own publishing facilities, to insure more adequate means of making the literature originating from its activities available to members and others in need of it. Probably no society, however, representing a rapidly expanding profession, is today finding it possible to supply means of publication as fully as needed. This is one of the most perplexing problems now confronting technical societies. However, there are indications that a concerted effort may eventually be made toward finding a solution; the pressing needs of these times for stepping up scientific and technical advancement may well result sooner or later in definite steps toward assisting the societies with their publishing problems.

What is being done — and what more needs to be done — in our organization, to meet our particular publication requirements?

AGRICULTURAL ENGINEERING was established in 1920 to provide more adequate publication of our reference literature than was then possible with the annual "Transactions," but the growing volume of papers presented at national and section meetings of the Society — and including special articles prepared expressly for the Journal — has long since exceeded our facilities. Journal space now being devoted to technical material consists mainly of those meeting papers and special articles that are considered as having the greatest value to the most members as reference literature. That is not to say, however, that we are printing *all* papers that merit publication. The combination of an increasing amount of material and higher publishing costs presents the Society with an exceedingly difficult problem ,the solution to which is still to be found.

Since it is not feasible to increase the size (number of pages) of AGRICULTURAL ENGINEERING beyond certain limits, consideration needs to be given to other forms of publication of meeting papers, committee reports, etc., not used in the Journal but which are important sources of new information needed by our members. Since much of this material has more or less temporary value for reference use, copies supplied in mimeograph or other forms of duplicating would doubtless meet most requirements. There is, however, an increasing number of papers, usually quite technical, that are useful for reference to a relatively small percentage of members. Such material could be supplied in the form of printed separates or in a revived "Transactions" published annually or at more frequent intervals.

The Divisions of the Society, specially their technical committees, along with the everyday technical problems confronting them as agricultural engineers, might well give more attention to our publications problem, for it is primarily a group problem and one that concerns every group in ASAE, large or small. The fund of technical literature, together with the combined experience of individual agricultural engineers, is what constitutes the working capital of our profession. Your contributions to the fund need to be preserved and made conveniently accessible so that all may draw on it.

The extent to which the number of pages in the Journal can be increased to provide more space for papers depends largely on the amount of advertising space scheduled. We aim to have reading matter and advertising apportioned about fifty-fifty. The proportion of space devoted to technical papers could be considerably increased were it not for the fact that we lean heavily on the Journal to help finance other than the strictly publishing activities of the Society. The Journal, therefore, must be published at a profit.

* * *

The choice of papers for use in AGRICULTURAL ENGINEERING is a responsibility which appropriate committees or groups of the Society should share with the editor, in order that a more adequate evaluation may be made of the material available for publication. As a means to this end, the proposed procedure appended to this report, for consideration of publishable material, was submitted last November to the Council and Division Executive Committees of the Society. This proposal is aimed primarily at providing more satisfactory selection of papers worthy of publication. It is believed to be a workable solution of this problem, and it is recommended that the Divisions and Sections proceed with implementing the plan.

* * *

The issuing of AGRICULTURAL ENGINEERS YEARBOOK begun a year ago has provided a much needed means for publishing a variety of information required by our members, and it appears to have been a timely and useful addition to our publishing activity. Perhaps its greatest advantage is in the convenience of having the material under one cover.

Just how permanent the Yearbook may prove in its present form and content is something that can be determined with a few years experience. The 1955 edition is 32 pages larger than the first (1954) edition, and with future editions becoming still larger, as we anticipate, the publication in time may become too bulky for practical use. However, when this point is reached, it is believed the contents can readily be divided into two separate publications and still be about as convenient and practical as in the present form.

* * *

Since AGRICULTURAL ENGINEERING was established, the aim has been to make it an increasingly profitable business publication as well as a technical journal, serving ASAE members, and the record since shows that this purpose has been achieved to a gratifying extent, though not yet as fully as will eventually be realized. As a result of its 35 years of publication, AGRICULTURAL ENGINEERING has gained general acceptance as a respected technical journal of which we can be justifiably proud. Its acceptance as an advertising medium by advertisers and advertising agencies has been most gratifying and is our assurance that continued progress in making it a more profitable publishing property can reasonably be expected.

Each year AGRICULTURAL ENGINEERING has been consistently showing increases in the amount of advertising carried, and 1954 was no exception though early in the year non-renewal of several of our best schedules made the outlook for another record-breaking year anything but promising. As it turned out, sufficient new schedules were obtained to offset the non-renewals.

Our purpose is to continue to improve AGRICULTURAL ENGINEERING as a profitable advertising medium, as well as a technical journal, because we consider it our best source of revenue for improving and expanding our over-all publication facilities.

AGRICULTURAL ENGINEERS YEARBOOK is still too new as a publishing venture to evaluate its possibilities as an advertising medium. Space sales in the 1955 edition exceeded those of the 1954 edition by 15 percent which is a gratifying increase. We expect the sale of advertising space to increase from year to year, and if the return from space sales is eventually sufficient to offset cost of publication, we will consider it quite an achievement.

The American Society of Agricultural Engineers is definitely in the publishing business, with all that the term implies, including greater opportunity (1) for serving the needs of its members for technical literature and other professional information and (2) for developing publications as producers of revenue to make them at least self-supporting. I am convinced these properties have promising potentialities for expansion.

Respectfully submitted

RAYMOND OLNEY, Publisher

June 14, 1955

* * *

Recommended Procedure for Considering Technical Papers for Publication in Agricultural Engineering

Technical manuscripts available for publication in AGRICULTURAL ENGINEERING derive mainly from four sources:

- Papers presented on Division-sponsored programs at ASAE national meetings
- Papers presented on meeting programs of ASAE Sections
- Papers, reports, data contributed and approved by ASAE Committees
- Original articles authored by ASAE members and others.

Consideration of manuscripts intended for use in AGRICULTURAL ENGINEERING involves three stages:

- *Evaluating* papers or articles from the standpoint of contributing timely new information of value to the expanding literature of the profession
- *Recommending* such improvement in publishable material as is necessary to enhance its value for reference use
- *Scheduling* of approved material for publication.

The *scheduling* of approved manuscripts for publication is largely a routine editorial function, in which several factors, such as demand, timeliness, variety of subject matter, space requirements, etc., have to be duly considered.

The main problem confronting the Editor—and one that explains the primary purpose of the procedure herein outlined—is need of the advice of experts (authoritative specialists):

(1) in *evaluating* individual manuscripts for publication and (2) in *recommending* also such improvement — revising, condensing, etc. — as may be needed to facilitate their use for general information or technical reference.

The most logical approach to a solution of the problem seems to lie in setting up special committees—"Papers Committees"—to take responsibility for directing the work of carefully appraising papers, articles, etc., and making recommendations pertinent to their publication in most useful form. The form of organization presented in the following paragraphs is recommended:

Division Papers Committees. It is recommended that each Division Executive Committee, possibly with the advice of the Division Steering Committee, form a "Division Papers Committee." The function of this committee is to provide the Editor with expert advice — given by its own members and/or other competent individuals—on papers and articles considered for publication in AGRICULTURAL ENGINEERING. The nature of such advice should be twofold(namely: (1) evaluate material available for publication and (2) suggest revisions that would enhance its value to readers.

Following ASAE annual and winter meetings, Division Papers Committees will be asked to appraise papers presented on programs arranged by their respective Divisions and report their opinions and recommendations concerning publication to the Editor.

In addition to papers presented on Division-sponsored programs, each Division Papers Committee will be asked to give similar counsel concerning the following publishable material, that is, within its subject-matter scope:

- Papers presented on ASAE Section meeting programs
- Contributions on ASAE technical committees
- Original articles by ASAE members and other authors.

Section Papers Committees. It is recommended that the Executive Committee of each ASAE Section be asked to form a "Section Papers Committee," the function of which would be (1) to consider the suitability for publication of *technical* papers presented on Section meeting programs and (2) to see that manuscripts of papers deemed worthy are submitted to the proper Division Papers Committees for further appraisal and recommendation concerning publication. (Non-technical papers and addresses before Section meetings could be submitted direct to the Editor by the Section Papers Committee.)

Personnel of Papers Committees. Each Division or Section "Papers Committee," as contemplated by this procedure, would function *primarily* as a "clearinghouse" and *secondarily* as a body of experts or authoritative specialists. For that reason the clearinghouse function may be facilitated if the personnel of each Papers Committee includes part or all of the members of the Division Executive and/or Steering Committees and of the Section Executive Committees.

The constituting of a "body of experts" to be members of or advisory to a Division Papers Committee, is likely to include Society members other than, and in addition to, those serving on the Executive and Steering Committees.

Latitude of Editor. Since the activity of Papers Committees will be carried on largely by correspondence, the procedure herein outlined may prove somewhat cumbrous, resulting in more or less delay in getting manuscripts approved and made ready in suitable form for publication. It is therefore understood that the Editor will exercise whatever latitude may be necessary in the selection and use of publishable material — prior to formal approval by Papers Committees — so as not to handicap monthly publication of the Journal.

Annual Report of the Treasurer for 1954-55

To the Council and Members of the
American Society of Agricultural Engineers:

The financial condition of the Society at the close of the fiscal year ending December 31, 1954, is shown by the Balance Sheet of Assets and Liabilities in the accompanying report of the auditor, Daniel W. Potter, CPA, of St. Joseph. (See page 408.) The report also covers total Society income and expense for the 12-month period.

Nothing portrays the growth of the Society as a business operation quite so vividly as the annual financial reports to the members, especially if a comparison of these reports from year to year is made. The Society business has been making substantial growth in recent years, and it is significant to note that in the 10 years since the close of World War II our annual income has almost tripled. Following is a tabulation of total receipts of income for each of the ten years, together with the percentage increase in each case over the preceding year:

1945—$	52,500—	20.6 percent
1946—	53,000—	9.5
1947—	59,000—	11.3
1948—	66,000—	11.8
1949—	71,000—	7.6
1950—	82,000—	15.4
1951—	99,000—	20.7
1952—	117,000—	18.2
1953—	133,000—	13.7
1954—	149,000—	12.0

In this same 10-year period the cost of operating our business has also increased. Up to and including 1952, however, the rate of increase in operating cost was appreciably lower than the increase in income, and as a result we were able to build a fairly substantial cash reserve of approximately $80,000, all of which is invested in United States Savings Bonds. The greater part of this reserve was accumulated in the 9-year period, 1944-52, during which time in excess of $67,000 in bonds were bought.

It needs to be pointed out, however, that during the past three years the margin between income and expense has begun to narrow perceptibly. With increases in personnel at our central office and growing demands for the services of the Society, the cost of operating our organization is now fast overtaking annual income.

To make certain that ASAE continues to maintain a sound financial condition, there is need to give early attention to ways and means of increasing our income to meet the larger expenditures called for by our expanding activities. It is certain that the members would not be in sympathy with operating our Society business on other than a balanced budget.

The stepping up of effort of recent months to increase new member enrollments is one means of adding to income, but it is the experience of organizations like ours that, unless high-pressure methods of membership enrollment are resorted to—and they are always highly questionable, to say the least — increasing income by adding new members is a relatively slow process.

Another step toward increasing income was taken January 1st when rates for advertising space in AGRICULTURAL ENGINEERING were increased approximately 18 percent. This action was in accord with usual publishing practice of raising advertising rates when warranted by gains in circulation and when required to meet upward trends in publishing costs.

Higher space rates for AGRICULTURAL ENGINEERS YEARBOOK were announced June 1st, and for the same reason. The new advertising rates on both Journal and Yearbook will not be in effect to any extent, however, until 1956.

Our publications possess considerable potential for increasing Society income. The past record of the Journal proves this. However, it is believed the interests of our members will be best served if most of the net revenue from the publications is used to improve and expand their usefulness.

A third means — though never a popular one — of increasing Society income is to raise membership dues. Ordinarily this should not be done, except as a last resort. However, in the face of growing demands for such services as we would all like to see the Society provide its members, and recognizing that these demands are increasing out of proportion to the increase in income, we are right now facing the stern choice of raising dues or restricting services. Given a choice, it is believed members generally would find increasing the dues less objectionable. It is quite general knowledge that most engineering societies in recent years have been forced to make substantial increases in membership dues. To meet the apparent general demand from members for more service rather than less — and at the same time make sure that outgo does not exceed income — it is difficult to see how a dues increase can be avoided.

All three of the principal sources of Society income — membership dues, Journal subscriptions, and Journal advertising — produced increases in 1954 over the preceding year, the over-all increase being approximately 12 percent. Contributing also to this increase was an $8,300+ item covering Yearbook advertising and copy sales.

Significant of the importance of the Journal in the financing of our Society activities is the fact that approximately one-half of our total income for 1954 was from the sale of advertising space. Add to this the credit for Journal subscription and copy sales and the record shows that the publication accounted for 64 percent of the total 1954 income.

The year 1954 broke another record for advertising sales in the Journal which was particularly gratifying, since the prospect at the beginning of 1954 was for a falling off in advertising during the year. The year closed with a $2500 increase over the preceding year.

The first (1954) edition of AGRICULTURAL ENGINEERS YEARBOOK was published at a loss — that is, the net return from advertising space and from the sale of copies of the publication to non-members was not sufficient to offset the cost of printing and distribution. This was not unexpected, specially since it was a first edition. Our goal, however, which we have been successful in more than reaching in the case of AGRICULTURAL ENGINEERING, is to net a return from advertising and copy sales in excess of production and distribution costs.

Against a 12 percent increase in total receipts for 1954 over the preceding year, must be recorded an 18.5 increase in total disbursements. The auditor's report shows that the 1954 fiscal year closed with a net gain or profit of $2,703.81. This is less than one-third of the profit for the preceding year, and emphasizes the point already made in this report, namely, that Society operating cost is fast overtaking income. Serious attention will need to be given to reversing this trend, but it is your treasurer's recommendation that this be accomplished, not by restricting the services of the Society to its members, but rather by developing ways and means of increasing income in order to *expand* our services.

Respectfully submitted

RAYMOND OLNEY, Treasurer

June 14, 1955

Auditor's Report for 1954

To the Council of the
American Society of Agricultural Engineers:

St. Joseph, Michigan, March 19, 1955

I have gone over the books and records of your society for the year 1954 and attach the following schedules: Assets and Liabilities, Receipts and Disbursements, and Bank Proof.

No change has been made in the U.S. Savings Bonds account, except that eight (8) $500 bonds falling due in late 1954 had been turned in for redemption, but the funds were not received until after December 31, 1954. The investment in additional bonds during these years of high income could well be discussed at your next meeting.

Receipts show 12 percent increase over 1953 due mainly to an increase in membership dues and to Yearbook advertising sales.

Books and records were found to be in very good order.

(Signed) DANIEL W. POTTER, CPA

BALANCE SHEET — DECEMBER 31, 1954

ASSETS

Current Assets:		
Checking Account (Peoples State Bank)	$17,634.79	
Reserve (U.S. Savings Bonds at cost)	79,382.00	$ 97,016.79
Medal Award Funds:		
Cash (Peoples State Bank savings account)	2,376.14	
Harvester and Deere Stock (at par)	10,500.00	12,876.14
Accounts Receivable		263.42
Inventory:		
Journal paper stock carry-over	1,800.00	
Publications	1.00	
Office equipment	1.00	1,802.00
Total Assets		$111,958.35

LIABILITIES

Accounts Payable (Employee Bonuses)		$ 2,300.00
Ferguson Foundation Fund		2,000.00
Meetings Contingent Reserve		1,408.59
Medal Award Endowment Funds		12,876.14
Earned Surplus Reserve (U.S. Savings Bonds)		79,382.00
Earned Surplus (Balance, December 31, 1953)	11,287.81	
Add Net Gain for 1954	2,703.81	13,991.62
Total Liabilities		$111,958.35

RECEIPTS AND DISBURSEMENTS FOR 1954

RECEIPTS

Miscellaneous Receipts	$ 386.02
Admission Fees	2,094.00
Membership Dues	39,486.45
Journal Subscriptions and Copy Sales	23,439.12
Journal Advertising Sales	72,973.86
Other Publication Sales	3,042.34
Yearbook Advertising Sales	7,375.65
Yearbook Copy Sales	929.97
Total	$149,727.41

DISBURSEMENTS

Miscellaneous Expense		$ 1,611.13	
Salaries		43,624.05	
Journal Expense		62,083.30	
General Printing and Supplies		7,253.97	
Postage		8,299.38	
Rent, Light and Janitor		3,220.67	
Telephone and Telegraph		891.07	
Traveling, Central Office Staff	$3,677.94		
Traveling, President	921.78		
Traveling, Other	371.22	4,970.94	
Meetings Expense		1,650.33	
Maintenance of Equipment		707.04	
Allied Organization Dues		155.61	
Taxes		479.48	
Employee Retirement Income Expense		937.14	
Office Equipment		723.32	
Michigan Hospital and Medical Service		786.19	
Yearbook Expense		9,629.98	147,023.60
1954 Net Gain to Earned Surplus			$ 2,703.81

BANK PROOF — THE PEOPLES STATE BANK

Checking Account (Bank Balance, December 31, 1954)	$23,703.85
Less Total of Checks Outstanding	6,069.06
Actual Balance Shown by Ledger	$17,634.79

NEW BOOKS

Agricultural Process Engineering, by S. M. Henderson and R. L. Perry. Cloth, ix + 402 pages, 5½ x 8½ inches. Illustrated and indexed. John Wiley and Sons, Inc. (440 Fourth Ave., New York 16, N. Y.) $8.50.

This is the third book in publication in the Ferguson Foundation Agricultural Engineering Series of texts. It broadens the foundation for professional training of agricultural engineers in agricultural processing, previously supplied only in part by texts on dairy engineering and other specialized subjects and by material available only in scattered references. It should contribute materially to realization that engineering is involved in processing agricultural products on a commercial scale; to recognition that this is agricultural engineering when the operation is handled on or near farms and influenced by agricultural considerations; and to the development of agricultural processing on an economically sound basis. Chapters cover the engineering approach, fluid mechanics, fluid-flow measurements, pumps, fans, size reduction, cleaning and sorting, materials handling, heat transfer, air-vapor mixtures (the psychrometric chart), drying, refrigeration, process condition observations, records, and controls, cost analysis, process analysis and plant design, and manual operation economy.

Farm Shop Skills in Mechanized Agriculture, by Sampson, Mowery, and Kugler. Cloth, 395 pages, 5½ x 8½ inches. Illustrated and indexed. American Technical Society (848 East 58th St., Chicago 37, Ill.) $4.95.

This new text and reference covers both the how and why of a wide range of farm shop, maintenance, repair, and minor construction jobs. Legends with illustrations outline steps in the jobs shown, to add to the reference value of the book. Chapters cover the farm shop, woodworking with hand tools, woodworking with power tools, painting of farm buildings and equipment, concrete and concrete masonry construction, soldering and pipe fitting, metal working on the farm, welding practices on the farm, fitting shop and farm tools, using electricity on the farm, maintaining farm machinery and farm shop projects.

Hydroponics: The Bengal System, by J. S. Douglas. Cloth xii + 147 pages, 5 x 7 inches. Illustrated and indexed. Oxford University Press, 114 Fifth Ave., New York 11, N. Y. $1.60.

This is apparently a reprinting, not indicated as revised, of a book first published in 1951, in which the author explains a system of soilless plant culture which he devised, and which he advocates as a solution to India's food problem. Chapters include introduction, how plants grow, apparatus, nutrient mixtures, the system in practice, general technique, commercial possibilities, common deficiencies, miscellaneous notes, and the future of hydroponics.

Elements of Soil Conservation, by Hugh H. Bennett (Second edition). Cloth x + 358 pages, 6 x 9 inches. Illustrated and indexed. McGraw-Hill Book Co., Inc. (330 West 42nd St., New York 36, N. Y.) $3.96.

This brings up to date an elementary nontechnical text and reference on the subject for use at vocational and high school as well as college general training levels.

(Continued on page 418)

Research Projects in Agricultural Engineering

[EDITOR'S NOTE: This list includes presently active research projects at agricultural colleges and experiment stations in which agricultural engineering is a major feature. Listing includes in the order given: *(a)* project title, *(b)* project number, and *(c)* year initiated (and revised). Write agricultural engineering departments of the respective colleges and universities for detailed information.]

University of Arkansas, Fayetteville

Ground Water, Resources and Recharge in the Rice-Growing Area of Arkansas, No. 106

Farm Home Improvement Through Practices and Methods for Obtaining Adequate Housing at Low Cost (coordinated with Southern Regional Project), No. 282

Asphaltic Stabilization for Subfloors (contributing project to Regional Project S-8), No. 369

Mechanization of Cotton Production, No. 254

Mechanization of the Production and Harvesting of Cotton in Arkansas, No. 280

Conditioning and Storage of Small Grains, Seeds and Legumes, No. 325

Engineering Phases of Supplemental Irrigation (Subproject 3), No. 312

University of Georgia, Athens

Peanut Breeding and Culture, Purnell 7; 1931

Cotton Mechanization, BJ-9, 3 (RRF, S-2); 1947

Mechanized Farming, BJ-9, 41; 1947

Control of Southern Blight on Peanuts, BJ-9, 68; 1953

Efficient Marketing of Peanuts, ES-3; 1949

Machinery and Instruments for Research Work, G-AEN-25; 1952

Mechanization of Peanut Production and Harvesting, CP-AEn-1; 1947

Development of Forage Crop Machinery, CP-AEn-3; 1951

Peanut Storage Studies, CP-AEn-4; 1952

Mulch Tillage Studies, C-AEn-12 (USDA cooperating); 1954

Irrigation Studies, C-AEn-11 (USDA cooperating); 1946 (1954)

Mechanization of a 100-Acre Conservation Farm Unit, C-AEn-14 (USDA cooperating); 1941 (1952)

Runoff Plot Studies, C-AEn-24 (USDA cooperating), 1937 (1953)

Watershed Runoff Studies, C-AEn-25 (USDA cooperating); 1940 (1952)

Grain and Seed Moisture Studies, C-AEn-8 (USDA cooperating); 1946

Grain and Seed Drying Investigations, C-AEn-9 (USDA cooperating); 1946

Rural Housing—Work and Storage Facilities, C-AEn-10 (USDA cooperating); 1953

Requirements and Facilities for Drying, Aerating and Storing Ear Corn and Small Grains, C-AEn-21 (USDA cooperating); 1954

Grain and Feed Storage Off the Farm, C-AEn-23 (USDA cooperating); 1954

Electric Brooding for Poultry, C-AEn-15; 1951

Development of Designs for Egg Coolers, C-AEn-16; 1946

Electrical Treatment and Growth of Young Chickens, C-AEn-18; 1953

Mechanical Methods for Cooling Poultry Houses in Hot Weather, C-AEn-22; 1954

Poultry Processing Plants, Equipment, and Facilities, C-AEn-20 (USDA cooperating); 1954

Agricultural Processing Plants, Facilities and Equipment, C-AEn-19 (USDA cooperating); 1954

A Study of Dairy Products Processing Plants, Equipment and Facilities, C-AEn-7 (USDA cooperating); 1952

University of Idaho, Moscow

Improvements in the Design of Farm Buildings; 1949

Irrigation Practices; 1954

Irrigation Practice for Beets; 1953

Mechanics of Water Control in Irrigated Land; 1954

The Development of Idaho Materials for Building Construction; 1947

Electricity in Relation to Agriculture; 1947

Irrigation Practices for Crops; 1953

Development of Stream-Flow Measuring Devices; 1953

University of Illinois, Urbana

A Study of Drainage in Plastic Till Soils in Northwestern Illinois, No. 201; 1948

Runoff from Small Agricultural Areas in Illinois, No. 202; 1950

Effect of Terrace (Operation of farm machinery on and across channel-type terraces), No. 204; 1949

Development of Methods for Production and Use of Crop Residues, No. 311; 1953

Improvement of Power Machinery and Labor Efficiency, No. 312; 1936

Crop Processing, No. 316; 1953

Application of Electric Power to Farm Operation (reduction of chore labor), No. 460; 1948

Removing and Metering Grains and Supplements from Bulk Storage, No. 461; 1953

Procedures and Equipment for Filling and Unloading Vertical Silos, No. 462; 1954

Farm Building Requirements and Design, No. 700; 1948

Study to Determine and Interpret Present Farmhouse Requirements, No. 707; 1949

Utilization of Aluminum Products in Farm Buildings and Equipment, No. 708; 1948

Purdue University, Lafayette, Indiana

A Study of Atmospheric Corrosion on Wire and Wire Products, No. 104; 1936

Soil and Moisture Conservation Studies, No. 124; 1948

V-Belt Study, No. 208-79, 1953

Crops Residue Management and Mulch Tillage Experiments, No. 236; 1945

Determination of Drying Rates of Grain in Bulk Air-Drying Systems, No. 273; 1946

Use of Radiant Energy and Electric Traps as a Possible Control for European Corn Borer and Other Insects, No. 357; 1947

Thermal and Moisture Properties of Floors in Farm Buildings, No. 390; 1949

Selection and Utilization of Materials for Farm Building Construction, No. 402; 1948

The Development of Bulk Hay-Drying Systems Utilizing Heat and Mechanical Ventilation, No. 452; 1950

Requirements of Electrical Radiant Heat Sources for Prevention of Baby Pig Losses, No. 509; 1949

Drainage Properties and Problems of Vigo, Clermont and Stendal Soils, No. 608; 1951

Mechanical Ventilation of Poultry Houses, No. 631; 1951

The Requirements of Radiant Electrical Energy Heating for Brooding Poultry, No. 632; 1951

The Development of Equipment and Methods for the More Efficient Conveying of Forages on the Farmstead, No. 634; 1953

A Comparison of Heated Mats with Straw as a Bedding for Calves, No. 637; 1951

A Determination of Design Requirements for Agricultural Machinery, No. 638; 1951

Development of Hydrologic Design Criteria for Irrigation Reservoirs in Southern Indiana, No. 654; 1952

The Relation of Drying and Storage Practices to the Deterioration of Grain, No. 742; 1954

Development of Building Panels and Materials from Vegetal Stems and Stalks, No. 761; 1954

Development of a Rapid Method for the Determination of the Oil Content of Commercial Oilseeds, No. 774; 1954

Iowa State College, Ames

Functional Design Requirements and Performance of Farm Equipment, No. 1160; July 1949

Harvesting, Processing, Storage, and Utilization of Forages, No. 1195; July 1950

Operation Cost of Farm Power Units, No. 1210; July 1951

The Operational Characteristics and Labor Requirements of Electrical Service, Wiring, Equipment, and Appliances for the Farming Enterprise (USDA cooperating), No. 1079; 1949

The Operational Characteristics and Labor Requirements of Electrical Service, Wiring, Equipment and Appliances for the Farm Home (USDA cooperating), No. 1081; 1948

Effect of Selected Building Materials Upon the Growth and Development of Swine, No. 1011; 1952

Selection and Utilization of Building Materials, No. 1036; 1950

An Investigation of Farm Building Losses Due to Wind and Fire, No. 1167; 1930

Development of Procedures and Instrumentation for Measuring Thermal Radiation as Related to Animal Comfort, No. 1244; 1952

Field Investigations of Subsurface and Surface Drainage, No. 1003; July 1954

Erosion Control and Water Conservation Investigations (USDA cooperating), No. 1064; July 1954

Irrigation Investigations in Iowa, No. 1247; July 1953

Physical and Economic Analysis of Watersheds as Related to Soil and Water Conservation (USDA cooperating) No. 1266; July 1954

Kansas State College, Manhattan

Durability of Farm Fencing (ASTM Bureau of Standards cooperating), No. 136; 1936

Cost and Depreciation of Farm Machinery, No. 121; 1932

Rural Electrification, No. 178; 1925

Farm Shop, No. 186; 1947

Irrigation, No. 203, 1948

Spraying Equipment for Weed Control, No. 189; 1948

Utilization of Liquified Petroleum Gas as a Tractor Fuel, No. 190; 1948

The Heat Pump, No. 191; 1947

Harvesting of Legume Seeds, No. 208; 1951

Ventilation of Grain in Storage, No. 235; 1953

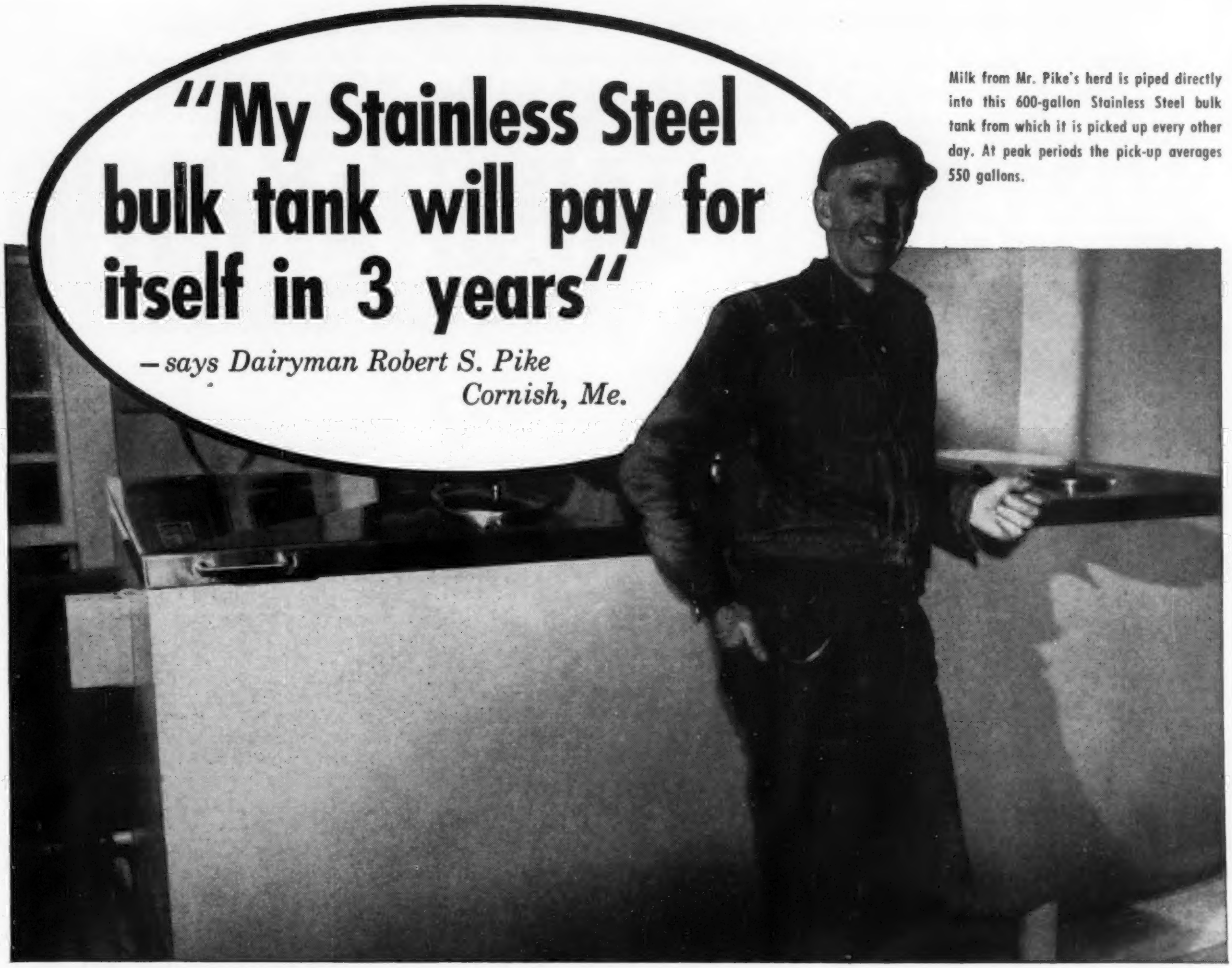
The Farm Water Supply, No. 398; 1954

Concrete in Silo Construction, No. 359; 1928 (1953)

Handling and Storage of Silage, No. 374; 1953

(Continued on page 412)

Milk from Mr. Pike's herd is piped directly into this 600-gallon Stainless Steel bulk tank from which it is picked up every other day. At peak periods the pick-up averages 550 gallons.



CURRENTLY milking a herd of 85 registered Jerseys, Mr. Pike has been using the bulk milk handling system since June 1, 1954. His 600-gallon Stainless Steel farm tank has already made possible an impressive list of savings.

1. Hauling charges have been reduced 5 cents per cwt.
2. Losses through stickage and spillage have been eliminated.
3. Cleaning up takes only 15 minutes. No more men are required to handle the herd which has more than doubled since can-handling days.
4. Butterfat count has improved one to two points.

These are the dollars-and-cents savings that Mr. Pike feels will make the Stainless tank pay for itself in 3 years. But don't overlook such other benefits as reduced bacteria count and the elimination of hard, physical labor.

Because of its economies, bulk milk handling with Stainless Steel farm tanks is one of the fastest growing trends in dairying today. It's an idea you'll want to be able to discuss with farmers in your area who are hearing about it.

For more information, mail the coupon below. United States Steel—as the producer of USS Stainless Steel from which bulk tanks are fabricated—has prepared a special booklet on bulk handling of milk. It's yours without obligation.

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Please send me the free booklet on bulk milk handling equipment.

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UNITED STATES STEEL

Research Projects in Agricultural Engineering

(Continued from page 410)

University of Maine, Orono

Bean Drying, State 60; 1952
Improved Mechanization for Storing Forage Crops, No. R&M 39; 1954
Increased Plant Stand of Blueberries, No. BT-6; 1952
Improvement of Quality and Efficiency in Processing and Marketing Low-Bush Blueberries, No. BT-9; 1953
Poultry Laying House Environment, No. Purnell-68; 1953
Potato Harvester Studies, No. Purnell-62 and PT-13; 1952
Maine Potato Handling Research Center, No. Purnell 62 and PT-13
Irrigation Studies, No. Purnell-58; 1950

Michigan State College, East Lansing

Frost Prevention, No. 6; 1945
Tillage Methods, No. 7; 1946
Supplemental Irrigation, No. 132
Sugar Beet Machinery Research, No. 137; 1944
Fertilizer Placement, No. 280; 1943
Farm Processing, No. 302; 1950
Baled Hay Handling and Storage, No. 303; 1947
Insecticide and Fungicide Application, No. 324; 1950
Grain Drying, No. 336; 1951
Onion Handling, No. 337, 1948
Plowshare Wear, No. 348; 1951
Surface and Subsurface Drainage, No. 411; 1951
Insulating Glass for Swine Housing, No. 424; 1951
Potato Handling, No. 436; 1952
Pea Bean Storage, No. 438; 1952
Unified Farmstead Operation, No. 455 (NC-23); 1948
Handling, Transportation and Storage of Agricultural Products, No. 437; 1952
Water Requirements of Plants, No. 805; 1955
Sediment Transportation, No. 806; 1955
Cathode Ray Studies, No. 807; 1952

University of Minnesota, St. Paul

Heat Pump Applications in Crop Processing, No. 114-4; 1953
A Study of the Properties of High Moisture Ensilage that Influence the Design of Silos, and a Study of Methods of Reducing Moisture Content of Ensilage Crops by Mechanically Expressing the Moisture from the Green Material, No. 136
Housing and Management of Dairy Cattle with Relation to Efficiency and Economy, No. 146; 1948
Field Shelling of Corn, No. 147(1); 1952
Low Volume Unheated Air Drying of Grain and Early Harvest Practices, No. 147(2); 1952
Draintile Capacities as Influenced by Flowage Characteristics, No. 148; 1954
Supplemental Irrigation in Minnesota, No. FH-2212-1; 1947
Design and Development of Equipment for Weed Control, No. FH-2212-2; 1948
Studies on Harvesting, Handling, Storage and Marketing of Table Stock Potatoes, No. FH-2221-M1; 1950

Mississippi State College, State College

The Effect of Cultural Practices on Physical Property of Soils, No. PB-5 (Federal) Purnell; 1954
The Effect of Supplemental Irrigation on Crop Production and Soil Properties in Mississippi, No. BB-1 (Federal) Bankhead-Jones; 1951
Studies on the Effect of Herbicides Upon Weeds and Crops, No. SwB-1 (State); 1949
Rotations and Crop Residues for Eroded Mississippi Farm Lands, No. BB-2 (Federal) Bankhead-Jones; 1954
Mulch Farming Requirements, No. FB-4 (Federal) Hope-Flannagan; 1952
Mechanized Harvesting and Feeding of Silage, No. FB-5 (Federal) Hope-Flannagan; 1954
Development and/or Improvement of Methods of Processing Major Agricultural Seeds, No. RMB-1 (Federal) Research and Marketing; 1953
Seed Production and the Development of Methods of Harvesting, Processing, and Storage of Legume, Pasture, and Forage Crop Seed, No. FB-2 (Federal) Hope-Flannagan; 1950
The Development of Equipment for the Application of Anhydrous Ammonia as a Fertilizer and as a Defoliant, and the Application of Liquid Fertilizers, No. SamB-1 (State) Anhydrous Ammonia; 1952
Fertilization and/or Seeding of Pasture Crops in a Pasture Sod, No. FB-3 (Federal) Hope-Flannagan; 1949
Farm Mechanization as Related to Hill Section of Mississippi, No. FB-1 (Federal) Hope-Flannagan; 1954
A Study of Different Masonry Building Materials and Methods of Erection for Outside Wall Construction and Their Effects on the Inside Temperature and Heat Loss in Farm Homes, No. RRFB-1 (Federal) Bankhead-Jones; 1954
Adapting, Construction and Air Conditioning of Poultry Houses for Most Economical Production, No. FB-6 (Federal) Hope-Flannagan; 1954

University of Missouri, Columbia

Irrigation and Tillage in Corn Production, No. 2a; 1955
Supplemental Irrigation on Improved Pastures, No. 2b; 1954
Machines and Methods for Intensive Rotations, No. 42; 1953
Terracing, No. 43; 1952
Influence of Climatic Factors on Shelter Requirements of Farm Animals, No. 66; 1946
Design of Farm Buildings and Equipment, No. 71; 1924
Environmental Requirements for Animal Shelters, No. 136; 1952
Forage Harvesting, Handling, Storage and Feeding, No. 138; 1953
Equipment and Procedures in Spraying for Control of Weeds and Brush, No. 153; 1951
Farm Water Supplies, No. 155; 1951
Storage and Use of Surface Water for Irrigation, No. 227; 1954

University of Nebraska, Lincoln

The Effect of Moisture Condensation (Sweating) on the Keeping Quality of Clean and Soiled Eggs in Cold Storage, No. 242B; 1949
Conditioning Grain in Bulk Storage by the Use of Unheated Forced Air, No. 307A; 1946
Conditioning Chopped Hay with Unheated Forced Air; 1951
Use of Radiofrequency, Infrared Energy and Other Forms of Electrical Radiation for Drying or Conditioning Farm Crops, No. 416; 1949
Planning Farmstead Buildings and Their Auxiliary Equipment, No. 477; 1954
Packaging Materials for Frozen Meat Storage; 1954
Rate of Use of Domestic Water on the Farm as It Affects the Design of Farm Water Systems; 1954
Investigation of the Power, Labor and Machinery Requirements for the Production of Corn in Nebraska, No. 281; 1948
Evaluation of Belt and Drawbar Performance Characteristics of New Tractors, No. 382; 1919
Evaluation of Factors Affecting the Efficiency of Farm Tractors and Power Units, No. 383; 1950
Water, Soil, Plant, Weather, Equipment Relationships in Crop Production on Irrigated Land in Nebraska, No. 352; 1950
Irrigated Ladino Clover Pasture for Dairy Cattle, No. 378; 1950
Cost of Pumping Irrigation Water in Nebraska, No. 354; 1950
Effects of Land Use and Farm Practices on Runoff, Erosion and Sediment Production in the Medicine Creek Watershed, No. 417; 1952

New Mexico College of A. & M. Arts, State College

The Development of Improved Methods and Equipment for Planting and Late Weed Control in Cotton Production, No. 157; February 1954
Water Requirements of Cotton Grown on Adobe Soils of the Mesilla Valley, New Mexico, No. 48; April 1952
Water Requirements of Cotton Grown on Light-Textured to Medium-Textured Soils in Mesilla Valley, No. 9-31; August 1954
Water Requirements of Alfalfa Grown on Adobe Soils of the Mesilla Valley, No. 101; March 1950

Cornell Agricultural Experiment Station, Ithaca, N. Y.

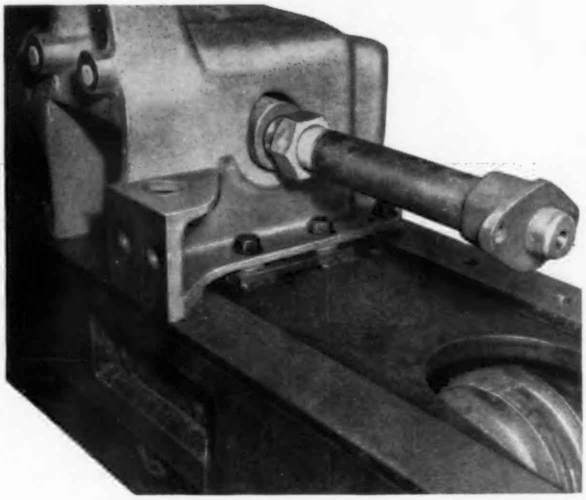
Exposure Tests of Farm Fencing, No. 20; 1936
A Study of Basic Requirements and Design Principles of Mechanical Equipment for Control of Insects, Diseases, and Weeds, No. 33; 1947
Exposure Tests of Steel Fence Posts, No. 42; 1950
A Study of the Factors Affecting Design, Costs and Operation of Irrigation Systems; the Interrelation of Water Application, Fertilization, and Production of Pasture Forage in New York State, No. 44; 1950
Drying of Grain and Forage Crops, No. 46; 1951
Investigation of Low Cost Stabilization Methods Suitable for Local Roads, No. 48; 1951
A Study of Methods for Reducing Fire Losses in Farm Structures, No. 50; 1951
The Adaption and Development of Farm Equipment for Efficient Handling and Processing of Diverse Products from the Farm Woodlot, No. 51; 1952
The Development of Materials Handling Methods and Equipment for Reducing Labor in Caring for Livestock, Including Reference to Harvesting, Processing, Storing and Feeding, No. 52; 1953
A Study of Methods and Equipment for the Storage and Handling of White Potatoes with Particular Emphasis on Preserving Quality, No. 53; 1953
An Investigation of Unconcentrated Spent Sulfite Liquor as a Gravel Road Binder, No. 54; 1953
An Investigation of Some Factors Affecting the Concentration of Silt and Clay Fractions at the Surface of Gravel Roads, No. 56; 1954
A Study of the Problems of Precooling Apples Preparatory to Refrigerated Storage, No. 71; 1954
Controls for Bulk Milk Coolers, No. 72; July 1954 *(Continued on page 420)*

A report to you about the men and machines that help maintain International Harvester leadership

NEW 300% stronger track frames for

INTERNATIONAL® CRAWLERS

...provide the "muscle" to resist shocks and stresses, cut operating cost!



Super-strong, direct-attached deep tillage equipment imposes tremendous stresses on crawler track frames. Bulldozing often stops a crawler abruptly "in its tracks," piles up *high impact* shock loads.

International Harvester engineers have developed new track frames to meet and beat such tough applications, years on end. Track rollers are securely mounted in the new frames between two rigid box-section weldments. The box sections themselves are welded in parallel alignment with extra thick steel plate at the top reinforced with heavy-duty vertical steel gussets between the rollers.

Result: 300% stronger track frames! They're bridge-strong and machined to keep tracks aligned with greater-than-ever lifetime precision—to provide non-twisting support for true-running track rollers and idlers! International crawler owners get increased capacity and uninterrupted performance. Results: lower upkeep, greater profits!

This new big crawler McCormick® mounted tool bar carrier permits hard ground subsoiling, as deep as 32 inches.

The blade for the International TD-14A crawler's combination carrier gives the farmer big material-moving capacity.

International Harvester engineering teamwork produced the new International crawler track frames. International Harvester research, engineering and manufacturing men are constantly pooling their time and talent to provide equipment that makes work easier and the farmer's time more productive.

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International Harvester products pay for themselves in use—McCormick Farm Equipment and Farmall Tractors . . . Motor Trucks...Crawler Tractors and Power Units...Refrigerators and Freezers—General Office, Chicago 1, Illinois.

NEWS SECTION

Stoddard Heads Alabama Section

LOWELL STODDARD, manager, Hanna Tractor Co., Birmingham, Ala., was elected the new chairman of the Alabama Section of the American Society of Agricultural Engineers at its regular spring meeting held at Dadeville, Ala., April 8 and 9. He succeeds F. A. Kummer, head of the agricultural engineering department, Alabama Polytechnic Institute.

The new vice-chairman of the Section is Lawrence Ennis, Jr., extension specialist in agricultural engineering, Alabama Polytechnic Institute. E. S. Renoll, assistant professor of agricultural engineering, API, is the new secretary of the Section. Hurst Mauldin, senior agricultural engineer, Alabama Power Co., was elected reporter of the Section.

The meeting opened on the afternoon of April 8 with a tour and demonstrations including a demonstration of surface irrigation and a tour of the Russell Manufacturing Company's plant. At the dinner in the evening the Section was addressed by Judge Jack Coley, who gave an interesting talk of the Indian battle at Horseshoe Bend. This was followed by a motion picture presented by Frank Lister of the Goodyear Tire and Rubber Company on the moving of materials and people by large conveyor belts.

The April 9 program featured three speakers and a panel of members of the Student Branch of ASAE at API. Interesting observations of engineering and agriculture viewed by a magazine editor were presented by Harold Benford of *Progressive Farmer*. This was followed by a discussion of the new county agent demonstration program by J. L. Lawson, associate director of the Alabama Extension Service. The results of some recent feed grinding and mixing tests were discussed by J. L. Butt, associate agricultural engineer, Alabama Agricultural Experiment Station.

The panel discussion participated in by members of the local ASAE Student Branch covered some of the problems which the students considered serious from their standpoint, one of which was the lack of knowledge among high school students in the southern states of the profession of agricultural engineering.

ASAE Meetings Calendar

May 26—GEORGIA SECTION, Fleming, Ga.

June 3-5—TENNESSEE SECTION, Montgomery Bell State Park, Tenn.

June 12 to 15—48th ANNUAL MEETING, University of Illinois, Urbana

August 22-24—NORTH ATLANTIC SECTION, University of Connecticut, Storrs

December 12 to 14 — WINTER MEETING, Edgewater Beach Hotel, Chicago

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

Oklahoma Meeting

THE spring meeting of the Olkahoma Section of the American Society of Agricultural Engineers was held at Chickasha, April 15, with more than 50 ASAE members and friends present.

Harry W. Pitzer, vice-president, Public Service Company of Oklahoma, opened the program of the meeting with a talk on the agricultural engineer's place in Oklahoma agriculture. He was followed by James E. Garton of the Oklahoma A. & M. College agricultural engineering department who talked on irrigation with a limited water supply.

Following this program the group were given a field trip in the vicinity of Chickasha to inspect demonstrations and other points of special interest to agricultural engineers. At the cotton research station, E. W. Schroeder, head of the Oklahoma agricultural engineering department, and members of the staff gave demonstrations and reports on research work being done on cotton mechanization.

Roy E. Hayman, agricultural engineer, Public Service Company of Oklahoma, served as chairman of the local arrangements committee.

A-E Curriculum in the Philippines

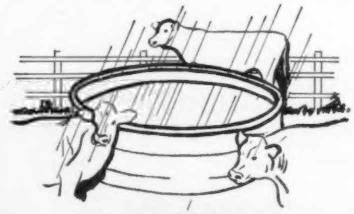
THIS month the Central Luzon Agricultural College, Nueva Ecija, Philippines, will offer a professional curriculum in agricultural engineering. This will mean the implementation of the aim of the college as contained in an order by the President of the Philippines to "provide professional, technical, and special instruction for special purposes, promote research, extension service, and progressive leadership in agricultural education, *agricultural engineering*, home economics and other fields." This curriculum is designed to meet the growing demand for professionally trained and competent men needed in the country's agricultural development through the application of engineering principles.

ASAE Alabama Section is welcomed to Dadeville for its meeting April 8 and 9 by County Agent Fletcher Farrington

Pictured here are 47 of the 65 ASAE members and friends who registered attending at the spring meeting of the ASAE Pennsylvania Section held April 14 and 15 on the campus of Pennsylvania State University

NEW

Zinc-Coated Tubing Offers Full Rust Protection



Have you avoided welded steel tubing in designing your farm equipment because you couldn't get the rust protection of a zinc coating? Now you can obtain Armco Steel Tubing made of ZINCGRIP, the special zinc-coated steel that provides unbroken rust protection.

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Available in Many Shapes. This zinc-coated tubing gives you an opportunity to make full use of the advantages of tubular parts in all kinds of farm equipment. It is supplied in rounds, squares, rectangular shapes, hexagons, octagons and special shapes, all with unbroken zinc coatings.

Rounds are produced in outside diameters from ⅝-inch through 3 inches, and in wall thicknesses of 20 gage through 12 gage, depending on size.

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NEWS OF ASAE MEMBERS

Russell R. Raney has accepted appointment as director of engineering of the New Idea Division, Avco Manufacturing Corp., Coldwater, Ohio, having resigned as assistant manager of engineering of the farm implement division of International Harvester Co.

R. R. RANEY

Mr. Raney is a 1934 mechanical engineering graduate of the University of Michigan. Upon graduation he accepted employment with International Harvester at its Auburn, N. Y., plant, and from there he was transferred to the company's McCormick Works at Chicago in 1941. He was serving as chief engineer at the McCormick Works in 1952 when he was promoted to the company's general staff as a divisional chief engineer. Since early 1954 he has been responsible for all of the company's advanced farm equipment engineering.

Mr. Raney attended the executive program of the University of Chicago and earned his M.S. degree in business administration in 1948. In addition to membership in ASAE, he is a member of Beta Gamma Sigma, the American Society of Mechanical Engineers and American Farm Economic Association.

Austin R. Cline was recently released from active duty with the U.S. Marine Corps, and is now employed by Shell Chemical Corp. at San Francisco.

ASAE Quad City Section officers at the annual meeting of the Section April 22. *(Standing, left to right)* C. S. Morrison, 1954-55 chairman, and new 1955-56 officers: G. W. Berryhill, secretary; M. E. Weakly, chairman; M. L. Love, treasurer; R. G. Morgan, chairman, nominating committee; R. E. Harrington, vice-chairman, and E. G. Rowlett, vice-chairman

National and section officers at the meeting of the ASAE Rocky Mountain Section at Logan, Utah, April 8 and 9. *(Seated, left to right)* ASAE Vice-President J. W. Martin, C. W. Lauritzen, soil scientist, U.S. Department of Agriculture, and ASAE President Geo. B. Nutt. *(Standing, left to right)* New Section officers for 1955-56—E. G. Hanson, chairman; G. O. Woodward, secretary, and N. A. Evans, vice-chairman—and S. H. Daines, program chairman for 1954-55 year

Harold M. Schudt was recently promoted from the position of assistant to the vice-president and director of engineering, Tractor Division, Allis-Chalmers Manufacturing Company, to that of president of Canadian Allis-Chalmers, Limited. From January 1948 to October 1954 Mr. Schudt was general manager of the company's Gadsden, Alabama Works.

H. M. SCHUDT

In his new capacity, Mr. Schudt will be in charge of operations which include general offices in Lachine, Quebec; manufacturing plants at Lachine and St. Thomas, Ontario, and sales offices in Montreal, Toronto, Winnipeg, Calgary and Vancouver.

Mr. Schudt started with the company in 1929 under an engineering cooperative program between the company and Marquette University. He graduated in 1932 with a mechanical engineering degree and in 1935 was transferred to the engineering department of the company's Tractor Division. In 1946 he was named a special representative for the Tractor Division's export department and spent two years in England where he started the company's first manufacturing operations at Southhampton.

Wylie E. Corbett, who has been on duty with the USAF, has now returned to civilian status and is employed as an engineer at the Savannah River plant of E. I. Du Pont de Nemours & Co. His new address is 116 Hudson Road, Aiken, S. C.

Marlin E. Weakly has resigned as product test engineer in the engineering test and development department at the East Moline Works of International Harvester Co., to accept employment as a junior designer in the product engineering department of the John Deere Harvester Works, East Moline, Illinois.

James A. Luscombe, who more recently has been engineer-in-charge of the Oklahoma Co-op Ginning Investigation, Oklahoma Cotton Research Station, Chickasha, on June 1 assumed the duties of engineer-in-charge of the Southeast Cotton Ginning Research Laboratory at Clemson, S. C.

Jack L. Sparks has resigned as irrigation engineer with the firm Michael Baker, Jr., Inc., to accept appointment with the University of Maryland U.S. Operations Mission to British Guiana. He will be employed in the capacity of irrigation and drainage engineer.

Daniel R. Denneler has been transferred from the position of agricultural engineer, U.S. Soil Conservation Service, Oswage City, Kans., to the position of survey and planning engineer on the Little Delaware Mission Watershed in Brown County, Kans. He will be located at Hiawatha, Kans.

James H. Strickler, who has been employed as an electric development representative of TVA, has recently accepted appointment on the agricultural engineering staff of Virginia Polytechnic Institute, Blacksburg.

Merle H. Peterson, a project engineer at the Racine, Wis., works of Massey-Harris-Ferguson, Inc., was recently promoted to chief engineer of the tillage division at the Racine works. *(Continued on page 418)*

PEORIA MALLEABLE CASTINGS "have a hand in the harvest" with GLEANER-BALDWIN COMBINES

Famous for performance and stamina, the Allis-Chalmers Gleaner-Baldwin line of combines is noted for its high quality construction. At many important points Peoria Malleable Castings are used.

Peoria Malleable castings provide an attractive part that is durable and dependable. And, very often, their cost is less than the labor and material involved in making a weldment or a forging.

Write for complete information. If you would like a definite quotation, at no obligation, enclose specifications with your letter.

A Gleaner-Baldwin self-propelled combine provides fast, efficient harvesting on this Midwestern farm.

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FAMOUS FOR ***QUALITY***

News of ASAE Members

(Continued from page 416)

John D. Cowsar, until recently employed as an agricultural engineer with Black, Sivalls and Bryson, Inc., at Kansas City, Mo., recently accepted appointment as instructor in agricultural engineering at the A. & M. College of Texas, College Station. In addition to his teaching duties he will be engaged in grain storage research.

Everett W. Todd, who has been chief engineer in the tillage division at the Racine, Wis., works of Massey-Harris-Ferguson, Inc., was recently appointed chief project engineer of the planting and cultivating engineering group at the company's Detroit works.

Paul C. Mortenson, who has been serving as executive engineer in the engineering department at the Racine, Wis., works of Massey-Harris-Ferguson, Inc., has been transferred to the engineering department of the company's works at Detroit, Mich., where he will serve as administrative engineer for the Western Hemisphere engineering division of the company.

Glenn M. Haslett, Jr., who has been employed as an agricultural representative of Caterpillar Tractor Company, together with Jim Watkins, a civil engineer, has recently formed the H. and W. Engineering Company of Indianola, Miss., which is offering farmers in that area a complete service in irrigation and drainage engineering, irrigation and drainage construction, and power farming.

William E. Swenson, who has been design correlator for the various engineering departments of the Minneapolis-Moline Company, was recently named assistant director of engineering for the company.

Mr. Swenson, following engineering studies at the University of Minnesota, joined the Minneapolis-Moline organization in 1926. After three years as a draftsman, he specialized in engine design, and in 1944 was named assistant chief engineer of automotive engineering. He became engineering coordinator in 1954 and has been engaged in integrating design of Minneapolis-Moline tractors, farm machines, and implements made at the company's plants at Minneapolis and Hopkins, Minn., Moline, Ill., and Louisville, Ky.

Marshall W. Loupo, until recently irrigation engineer for the Carloss Well Supply Co., Memphis, is now manager of the irrigation division of Tri-State Albany, Inc., a retail dealership at Albany, Ga.

Robert W. Louden, formerly vice-president and general manager of the farm line, The Louden Machinery Co., has announced that the newly formed Fairway-Factory Division of the Robert W. Louden Co. has been appointed exclusive Iowa distributor of the Westcoaster line of electric cars for golf and industry.

NECROLOGY

Charles Deere Wiman, a member of ASAE since 1929, and president of the Deere & Company since 1928 (with exception of two and one-half years during World War II), and a great grandson of John Deere, the company's founder, died in Tucson, Ariz., May 12, after an extended illness.

CHARLES D. WIMAN

Widely known as a leader in the farm equipment industry, and former president of the Farm Equipment Institute, Mr. Wiman also had many other business interests. He had been active in the International Chamber of Commerce, and at the time of his death was a member of boards of directors of various organizations, including the Continental Illinois National Bank & Trust Co. of Chicago, the Rock Island Lines, the Hilton Hotels Corp., and the Protection Mutual Insurance Co.

Mr. Wiman was born on Staten Island, N. Y., February 11, 1892, the son of William Dwight and Anna Caroline Deere Wiman. His mother was a daughter of Charles H. Deere, only son of John Deere and second president of Deere & Co. He married Pattie Harris Southall in Huntsville, Ala., April 12, 1920. She survives, as do their two daughters, Mrs. William A. Hewitt of Moline, Ill., and Mrs. William M. Brinton of San Francisco, and three grandchildren.

Mr. Wiman joined the John Deere organization in 1915, and was a shop employee at the John Deere Plow Works for a brief period before returning to Yale University as assistant coach of the Yale crew, of which he was a former member. When the National Guard was called to the Mexican border in 1916, he enlisted in the Civilian Military Aviation Training Camp at Governor's Island, N. Y. He received a pilot's license in the Aero Club of America and flew for three months before being injured in an airplane accident in September, 1916.

Following his recovery he returned to Deere & Co., but shortly before the United States entered World War I he enlisted in the regular army and was commissioned as a second lieutenant. Promoted to first lieutenant and then captain of field artillery, he served with the Third Field Artillery which for eleven months was in the Sixth Division of the American Expeditionary Forces.

Released from the army in October, 1919, Mr. Wiman was a shop employee, later superintendent, and then general manager of the Union Malleable Iron Co., a Deere & Co. subsidiary. In 1924 he was elected vice-president in charge of factory operations for Deere & Co., and in 1928 he became the company's fourth president.

In June, 1942, Mr. Wiman resigned the presidency of Deere & Co. in order to join the staff of General Levin H. Campbell, chief of ordnance, with the rank of colonel. In January, 1944, he was placed on inactive status by the army at the request of the War Production Board, in order to become director of the WPB farm machinery and equipment division. He held that position until July 7, 1944, when he asked to be relieved of his duties in order to regain his health after a severe attack of pneumonia.

Mr. Wiman returned to Deere & Co. in November, 1944, and was re-elected president. Burton F. Peek, president during Mr. Wiman's absence, was named chairman of the board.

Funeral services were held in Moline, May 16. Burial was in the Deere family lot in Moline's Riverside Cemetery, near the graves of John and Charles Deere, Mr. Wiman's great grandfather and grandfather.

NEW BOOKS

(Continued from page 408)

SAE Handbook (1955 edition). Cloth, 1094 pages, 8½ x 11 inches. Illustrated and indexed. Society of Automotive Engineers (29 W. 39th St., New York 18, N. Y.)

New standards, recommended practices and reports, included in this edition apply to classification of rigid plastic molding materials, multi-viscosity number oils, diesel fuels, fuel injection tubing, fuel supply connections, semiautomatic headlamp-beam switching devices, motor truck instrument panel grouping, rear wheel guards, truck overall widths across dual tires, turning ability and off-tracking, fuel systems, wheel mounting elements for 8-bolt, 8-in bolt circle farm equipment disk wheels, interchangeability of disc halves for agricultural press and gage wheels, agricultural tractor power take-off definitions and terminology, industrial tractor mounted equipment nomenclature (bulldozer), construction and industrial vehicle test codes, and hydraulic power pump test code.

Handbook of Drainage and Construction Products. 592 pages; 380 illustrations; 6 x 9 inches. Published by Armco Drainage & Metal Products, Inc., Middletown, Ohio. $5 postpaid.

This new edition of a book that was first published a quarter of a century ago is a comprehensive technical treatment of the design and engineering application of a number of widely used drainage and construction products.

Purpose of the book is to aid engineers in solving drainage problems and related engineering construction problems, also to enlighten students in practical modern drainage and other construction problems.

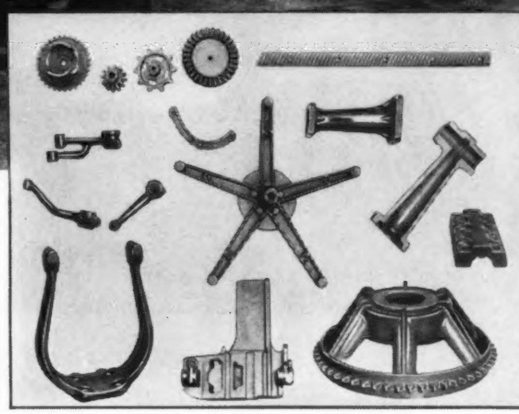
In 10 sections and 64 concisely written chapters it covers strength research; strength design; durability studies; durability design; economic factors; design principles and practice; subsurface drainage; special drainage problems; miscellaneous problems; and installation instructions. In addition there is a section of conversion tables and general tables, an appendix summarizing research on underground conduits, and a well organized index for quick and easy reference.

A typical section, Design Principles and Practices, indicates the thoroughness of the work. The thirteen chapters of this section deal with hydrology; design of open channels; theory of critical flow; design of culverts or cross drains for size and shape; culvert location and length; highway surface drainage; railway surface drainage; culverts under levees and dikes; end finish of culverts; design of sewers for size; hydraulics of sewers; sewer appurtenances; and part circle culverts.

Each chapter is summarized at the beginning and each illustration is referred to in the text.

The Heating Ventilating Air Conditioning Guide 1955 (33rd edition). American Society of Heating and Air-Conditioning Engineers, 62 Worth Street, New York 13, New York, $12.00. This is larger and improved in content over previous editions. The technical section is 1160 pages,

Changes include several rewritten chapters, a new chapter on schoolhouse heating and ventilating, new information on heating systems using high temperature hot water, and reorganized design information on thermal conductivities and conductances for pipe insulation and building materials.



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See how this economical iron . . . several times stronger than gray cast iron, and up to 12 times tougher . . . can improve *your* products. You may find several practical answers in the new INCO booklet "DUCTILE IRON, The Cast Iron THAT CAN BE BENT!" A copy is yours for the asking. Write for it now.

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Research Projects in Agricultural Engineering

(Continued from page 412)

North Carolina State College, Raleigh

Tobacco Mechanization, No. St-RM-48; 1948 (1954)

Fundamentals of Tobacco Curing, No. RM-23; July 1952

Engineering Studies in Tobacco Curing, No. S-61; January 1948

Cotton Mechanization, No. RRS-2, RM-42, RM-16; June 1947 (January 1955)

Development of a Concrete Tank for Farm Storage of Nitrogen Fertilizer Solutions, No. SE; January 1954

A Study of Surface and Subsurface Drainage, No. St-RM-3; April 1945

Tobacco Irrigation, No. S 131-E17; July 1950

Peanut Mechanization, No. SE-13; July 1947

Artificial Drying of Peanuts, No. SE-9; March 1950

Hay Drying, No. SE-3; 1946

Hay Machinery, No. SE-18, 1948

Farm Structures for Storage of Ear Corn, No. St-RM-11; August 1949

North Dakota Agricultural College, Fargo

Poultry House Ventilation and Litter Management Methods to Provide Dry Litter, No. B-J 34; 1951

The Development and Testing of Equipment to Measure the Resistance of Potatoes to Bruising and Injury, No. B-J 37; 1949

The Cost of Performing Tractorized Farm Operations and the Energy Requirements of Such Operations, No. B-J 41; 1952

Water Use and Erosion Under Irrigation, No. B-J Offset 92; 1949

Mechanical Handling of Silage and Grain from Storage to Feed Bunks in Open Feed Lots (in operation with Regional Project NC-23), No. B-J Offset 125; 1953

Ohio State University, Columbus

The Development of Equipment and Evaluation of Agricultural Aircraft, No. R&M 39; 1951

A Study of the Harvesting and Storing of Corn and Small Grain, No. R&M 38; 1950

The Production, Processing and Utilization of Native Timber for Farm Buildings, No. State 263; 1952

Interrelationships of Crop Rotations, Organic Matter Imput, Soil Structural Conditions and the Internal Drainage Characteristics of Soils, No. R&M 10; September 1947

Tillage Practice in Relation to Soil Tilth and Crop Response, No. B. J. 23; January 1952

Equipment for the Eradication or Control of Weeds or Undesirable Plants, No. R&M 20; February 1949

Investigation of Combine Cutterbar Losses; October 1951

Factors Affecting Shelling of High-Moisture Corn, October 1952

Oklahoma A. & M. College, Stillwater

Mechanized Cotton Harvesting in Oklahoma (USDA cooperating), No. 578; 1947

Engineering Features of Supplemental Irrigation, No. 622; 1948

Development of Farm Structures Recommendations, Plans and Specifications, No. 633, 1948

Temperature Control in Dairy Cattle Loafing Barns, No. 677; 1949

Design and Construction of Farm Equipment, No. 678; 1949

Adaptation of Storage Structures for Mechanical Conditioning of Crops, No. 679; 1949

Mechanization of Castor Bean Production (USDA cooperating), No. 733; 1950

Adapting and Testing Cotton Ginning Equipment and Techniques (USDA cooperating), No. 753; 1950

Runoff Characteristics of Agricultural Areas (USDA cooperating), No. 758; 1952

Hydraulics of Conservation Channels (USDA cooperating), No. 759; 1950

Control of Woody Vegetation, No. 789; 1947

Farm Water Supply Development, No. 798; 1951

Poles for Framing Farm Buildings, No. 800; 1951

Development and Improvement of Machines and Methods for Seedbed Preparation, Planting and Early Weed Control in Cotton Production, No. 802; 1952

Design, Development and Testing of Fertilizer Placement Equipment, No. 815; 1952

Ventilation and Temperature Control in Broiler Production Houses, No. 834; 1953

Ontario Agricultural College, Guelph

Effect of Tillage Methods on Crop Yields and Soil Conditions, No. AE5

Effect of Deep Tillage Machinery on Crop Yields on Haldimand Clay Soil, No. AE18

Studies on the Operation of Machines Used in the Seeding of Grasses and Legumes, No. AE11

Methods of Seeding and Seedbed Preperation, No. AE22

Frost Proofing Watering Bowls; Milking Room Heating, No. AE20

Runoff from Small Watersheds, No. AE15

Permeability and Water Table Conditions as a Basis for Drainage Design, No. AE17

Irrigation Water Supply Survey, No. AE25

Poultry House Ventilation, No. AE19

Engineering Tests of Grain Elevators, No. AE21

Temperature and Pressure Effects Produced by Silage, No. AE23

Utilization of Sheathing and Roofing Materials in Portable Farm Structures, No. AE24

Air Distribution in Hay Driers, No. AE26

Effect of Hay Handling Methods and Moisture Content of Nutrient Loss, No. AE27

Static Pressure Losses in Hay Driers, No. AE28

Basic Hay Drying Experimentation, No. AE29

Pennsylvania State University, University Park

Investigations of Newer Materials and Schedules for Spraying Potatoes, No. 754; 1928

Atmospheric Corrosion Tests of Wire and Wire Products, No. 925; 1927

Protective Coatings for Farm Buildings, No. 1020; 1944

Renovation of Unproductive Pastures, No. 1024-D, 1944

Handling Chopped Forage, No. 1053; 1946 (1950)

Economic and Physical Factors Affecting Efficiency in the Production of Eggs and Poultry Meat, No. 1061; 1946

Factors Involved in the Preparation of Freezing, Storing and Preparation for Serving of Foods, No. 1065; 1945 (1947)

Factors Affecting the Market Quality of Dressed and Drawn Poultry, No. 1078; 1947

Tillage Tool Design and Performance, No. 1083; 1947

Weed Control in Corn by Pre-Emergence and Postemergence Herbicidal Treatments and Cultivation, No. 1095-A; 1948

The Farm Shop in Mechanized Farming, No. 1140; 1950

Environmental and Management Factors Affecting the Quality of Poultry Meat and Eggs, No. 1148-A; 1951

Handling and Processing Grain on the Farm, No. 1196; 1954

(Contoinued on page 422)

Research Projects in Agricultural Engineering

(Continued from page 421)

Air Distribution in Drying Hay and Grain, No. 1198 (NE-13); 1954

The Quality Control of Raw Milk Supplies, No. 1201; 1953

A. & M. College of Texas, College Station

Mechanization of Cotton Production, Harvesting and Processing in Texas (contributing to Regional Project S-s)

Nozzle Arrangements and Types to Obtain Spray Patterns for Thorough Coverage of Cotton Plants with Insecticides and Defoliants

Storage of Cotton Seed for Planting Purposes

Pink Bollworm Control

Drying and Storing Sorghum Grains and Rice in Farm Storage Bins

Desirabilty of Materials and Methods of Installation for Floor Coverings, Drainboard Surfaces, Floor and Wall Finishes, and Wall Coverings (contributing project to S-8)

Development of Construction Techniques for Tilt-Up Farm Structures

Electric Refrigeration Equipment

Electric Equipment in Plant Production

Electric Equipment in Poultry Production

The Design, Installation, and Operation of Electric Water Warming Equipment for Livestock

The Efficiency of Various Types of Insulators for Electric Fences

Performance Characteristics of Evaporative Coolers in Hog Houses

Supplemental Irrigation in East Texas

University of Vermont, Burlington

Mechanical Collection of Maple Sap, No. State 54; July 1954

Mechanical and Structural Aspects of Harvesting, Curing, Housing and Removal from Housing of Grain, Hay, Silage and Bedding, No. Purnell 106; July 1948

Virginia Polytechnic Institute, Blacksburg

Development of Plans and Designs for Virginia Farm Homes; 1947

Improved Tobacco Curing Barns and Facilities; 1948

A Study of the Value and Adaptability of Aluminum to Farm Construction; 1952

Drainage Requirement and Practices for Crop Production; 1945

Hydrologic Characteristics of Agricultural Areas and Their Relation to Soil Conservation, Flood Prevention, and Water Yield; 1939

Improved Practices of Controlling Soil Erosion and Runoff; 1945

Irrigation Requirements and Practices for Crop Production; 1949

Brooding Chicks with Infrared Lamps; 1949

Studies of the Value of Electric Traps and Radiation for the Control of Hornworms on Tobacco; 1953

Development of Design Information for Poultry House Ventilation Under Virginia Conditions; 1954

Evaluation of Locally Fabricated, Walk-In-Type Farm Refrigerators; 1947

A Study of Automatic Washing Machines; 1952

Methods of Farm Curing and Drying Mechanically Harvested Virginia Type Peanuts; 1946 (1954)

Peanut Production and Harvesting Machinery; 1953

Drying and Storing Grain on Farms in the Eastern Tidewater Region; 1954

(Continued on page 430)

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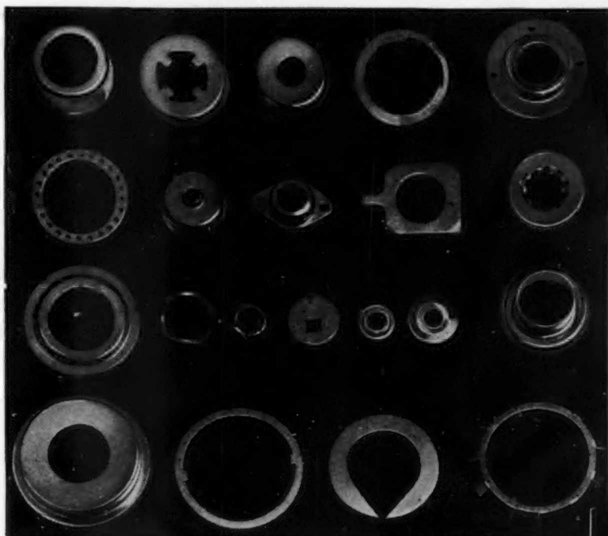

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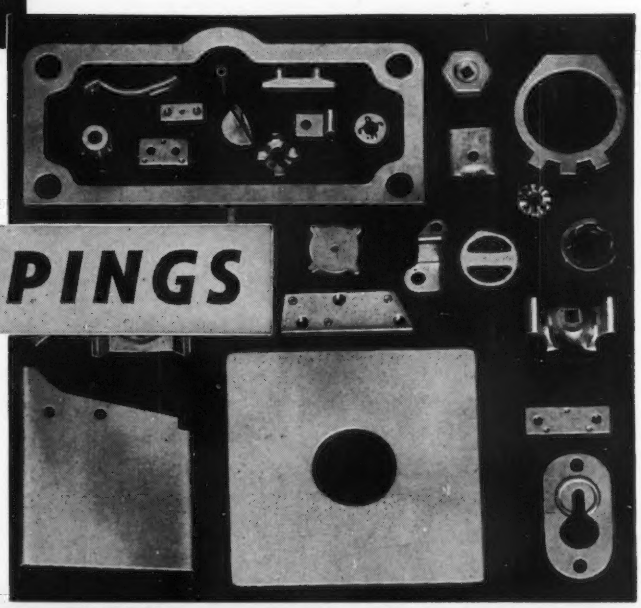

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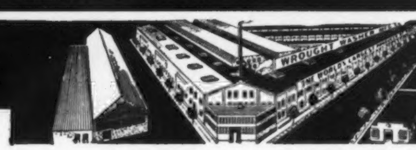

A8247-IP

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Andrews, H. A.—Assistant zone manager, International Harvester Co. (Mail) Box 47, Milldale, Conn.

Beaumier, Marcel—Manager, farm machinery div., La Cooperative Federee de Quebec, 105 St. Paul St., E., Montreal, Quebec, Canada

Blight, David P.—Research assistant in agricultural engineering, Stephenson Bldg., King's College, Newcastle-on-Tyne 2, England

Body, John H.—Student in agricultural engineering, Pennsylvania State University. (Mail) Yellow House, Pa.

Boston, William J.—Student in agricultural engineering, Oklahoma A. & M. College, Stillwater, Okla. (Mail) 19-1 Brumley

Boutwell, Robert B.—Student in agricultural engineering, University of Vermont, Burlington, Vt. (Mail) 21 University Rd.

Carnahan, Herbert E.—Student in agricultural engineering, California State Polytechnic College, San Luis Obispo, Calif. (Mail) 59 Vetville

Case, Eugene H.—Director of college and university relations, Deere & Co. (Mail) 140 Norfolk Rd., Waterloo, Iowa

Coronado, Francisco X.—1st Lt., USAF. (Mail) Box 6234, Mather Field, Calif.

Crafts, Barry S. — Student in agricultural engineering, University of Maine. (Mail) Sangerville, Me.

Craven, Wilmer C.—Manager, diesel engine and farm machinery branch, E. F. Craven Co., Greensboro, N. C. (Mail) 2513 Oakcrest Ave.

Davis, Charles A. Jr. — Design engineer, U.S. Forest Service, Yreka, Calif.

Dordahl, Alvin M.—Engineering representative, National Rain Bird Sales & Engineering Corp., Azusa, Calif. (Mail) P.O. Box 46

Ekstedt, William C.—Assistant to agriculturist, Western Massachusetts Electric Co., 73 State St., Springfield, Mass.

Evans, Layton C. — Agricultural engineer, The John Deere Plow Co., 339 S. Front St., Memphis 3, Tenn.

Fink, Harry A. Jr.—Student engineer, product development dept., Deere & Co. (Mail) RR 11, Lafayette, Ind.

Florin, James S.—Assistant engineer, Allis-Chalmers Manufacturing Co. (Mail) 654 Johnson St., Winona, Minn.

Frost, Gerald G. Jr.—Ensign, U.S. Navy. (Mail) 124 N. Broad St., Norwich, N.Y.

Hawkins, Clifton J.—Student in agricultural engineering, Mississippi State College. (Mail) RR 2, Box 67, Clarksdale, Miss.

Hays, Carl V. — USAF. (Mail) General Delivery, Pennsylvania State University, University Park, Pa.

Huber, Albert L.—U.S. Navy. (Mail) RR 1, Meridian, Ida.

James, Howell N.—Product engineer, International Harvester Co. (Mail) 1000 22nd St., Moline, Ill.

(Continued on page 426)

Applicants for Membership

(Continued from page 424)

Jenson, Clifford L.—Student in agricultural engineering, Oregon State College, Corvallis, Ore. (Mail) 626 S. 16th St.

Johanning, Joseph W.—Metal buildings engineer, Inland Steel Products Co. (Mail) 5596 Butternut Court, Greendale, Wis.

Knisel, Walter G. Jr.—Instructor in agricultural engineering, New Mexico College of A. & M., State College, N. M. (Mail) Box 268

Lange, Jack E. — Farm sales supervisor, Pennsylvania Power & Light Co. (Mail) 516 Harding Ave., New Cumberland, Pa.

Lear, John W.—Student in agricultural engineering, University of Vermont. (Mail) 550 Fairmount Ave., Chatham, N. J.

Ludwig, J. Robert—Chief engineer, clutch div., Dana Corp., Toledo 1, Ohio

McVey, Fred E. — Assistant chief, electric operations & loans div. (REA), USDA, Washington 25, D. C.

Matthews, John W.—Assistant professor of agricultural engineering and vocational agriculture, University of Illinois, Urbana, Ill.

Meuler, Robert F.—Draftsman, J. I. Case Co., Burlington, Iowa. (Mail) 942 S. Starr Ave.

Montague, William R.—Manager, Carolina Tractors, Inc., Goldsboro, N. C. (Mail) RR 1

Mortenson, P. C.—Administrative engineer, western hemisphere, Massey-Harris-Ferguson, Inc., Box 322, Roosevelt Park Annex, Detroit 32, Mich.

Narayanaswamy, Sholinghur—Assistant soil conservation officer, Government of India Research Centre, Ootacamund (The Nilgiris), S. India

Keller, Jack—Irrigation engineer (ARS), USDA, Fort Collins, Colo. (Mail) 25 W. Laural

Kidnocker, John D.—USAF. (Mail) Waverly Pike, RR 5, Chillicothe, Ohio

Nir, Dov—Associate lecturer in agricultural engineering, Israel Institute of Technology, Haifa, Israel

Paradysz, Louis Jr.—Farm equipment dealer, Holyoke Farm Machinery, Inc. (Mail) Hadley, Mass.

Ransom, John—Director of product research and education, Minneapolis-Moline Co. (Mail) RR 2, Wayzata, Minn.

Robinson, John J.—Student in agricultural engineering, Pennsylvania State University. (Mail) 259 Linden Ave., Towson 4, Md.

Robinson, John T.—Sales manager, Greer Hydraulics, Inc., International Airport, Jamaica 30, N. Y.

Rowen, Kenneth A. — Graduate student in agricultural engineering, South Dakota State College. (Mail) Saint Lawrence, S. D.

Smallegan, Marvin L.—Production manager and vice-president, Automatic Poultry Feeder Co., Zeeland, Mich. (Mail) 155 S. Sanford

Sorlie, Donald T.—Assistant engineer, tractor div., Allis-Chalmers Manufacturing Co., Milwaukee 1, Wis.

Stanhope, Harry W. — College trainee, Goodyear Tire and Rubber Co. (Mail) Robbinston, Me.

Stentz, Thomas D.—District manager, International Harvester Co., 1017 Maclay St., Harrisburg, Pa.

Stephens, John C. — Project supervisor (ARS), USDA. (Mail) Plantation Field Laboratory, 5305 S.W. 12th St., Fort Lauderdale, Fla.

Stevens, William F. — Assistant general sales manager, Starline, Inc., Harvard, Ill. (Mail) 606 N. Hart

Stiles, David N. — Farm youth specialist, The Connecticut Light & Power Co. (Mail) Mountain Rd., RR 1, Cheshire, Conn.

Thieken, Louis J. — Automotive engineer, The Standard Oil Co. (Ohio). (Mail) 3456 Muddy Creek Rd., Cincinnati 38, Ohio

Turnbull, John E.—Agricultural engineering fieldman, Ontario Dept. of Agriculture. (Mail) Western Ontario Agricultural School, Ridgetown, Ont., Canada

Vickers, William F. — Sales development consultant, industrial power div., International Harvester Co. (Mail) 2629 Park Lane, Glenview, Ill.

Warner, Ignacio — Agricultural engineer, Soriano & Co. (Mail) D563 Esq. 25, Vedado, Havana, Cuba

Woodrum, Earl H.—Design engineer, Allis-Chalmers Manufacturing Co., Springfield, Ill. (Mail) 3141 S. Douglas

Wuellner, Clifford S.—Field engineer, J. I. Case Co., Burlington, Iowa. (Mail) 1100 S. 8th St.

Zander, Albert A.—Trade promotion and advertising, West Coast Lumbermen's Assn., 1410 S.W. Morrison St., Portland 5, Ore.

(Continued on page 428)

Applicants for Membership

(Continued from page 426)

Transfer of Membership Grade

Eichelberger, Walter J. — Sales engineer, Food Machinery & Chemical Corp., Lakeland, Fla. (Mail) 125 Cherry Place. (Associate Member to Member)

Greenberg, M.—Engineering assistant, Department of Agriculture, 240 23rd St. E., Saskatoon, Sask., Canada. (Affiliate to Associate Member)

Lambert, Ralph C. — Distributor service manager, Florida Ford Tractor Co., P.O. Box 1258, Jacksonville, Fla. (Affiliate to Member)

Libby, Carl F. — Agricultural engineer, Northeast Agricultural Engineering Service, Hampden, Mass. (Associate Member to Member)

Lund, Carl M.—Assistant agricultural engineer, Clemson Agricultural College, Clemson, S. C. (Mail) Apt. 3D, N. Palmetto Blvd. (Associate Member to Member)

Richardson, Boone Y.—Assistant professor of agricultural engineering, Alabama Polytechnic Institute, Auburn, Ala. (Associate Member to Member)

Morris, W. H. M.—Assistant professor of agricultural economics, Purdue University, Lafayette, Ind. (Associate Member to Member)

Wilson, Philip H.—District agricultural engineer, New York State College of Agriculture, Ithaca, N. Y. (Associate Member to Member)

PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN—JANUARY—O-437-667, 438-668, 447-672. FEBRUARY—O-19-704, 32-705, 33-706, 18-709. MARCH—O-55-710, 61-713, 71-714, 87-715. APRIL—O-120-716, 142-717, 125-718, 155-719, 143-720, 173-721. MAY—O-200-722, 197-723, 180-724, 196-725, 205-726, 214-727, 214-728.

POSITIONS WANTED—DECEMBER—W-391-164, 411-166. 1955—MARCH—W-17-2, 48-4, 84-5, 27-6. APRIL—W-114-8, 129-9, 4-10, 133-11, 134-12, 67-14. MAY—W-154-15, 165-16, 177-17, 185-18, 176-19, 193-20, 206-21, 182-22, 213-23.

NEW POSITIONS OPEN

AGRICULTURAL ENGINEER (rating assistant professor and assistant agricultural engineer in the agricultural experiment station), for teaching soil and water conservation and either farm structures or farm power and machinery; and for research in irrigation and drainage, in a land grant college in a north central state. Age 25-40. MS deg in agricultural engineering, or equivalent. Several years of teaching, research, or extension work in soil and water field. Good personality and interest in teaching and research. Good opportunity for advancement. The man selected will be responsible for developing the teaching and research programs in the soil and water field. New agricultural engineering building with well equipped soil and water conservation laboratory. Salary open. O-243-729

AGRICULTURAL or mechanical engineer to head up development department in young aggressive sprinkler irrigation corporation. Residence to be required in the state of Washington and a small amount of traveling would be necessary. Engineer should have excellent background in manufacturing processes and should be capable of carrying new ideas through the development and experimental stages to final production. Should be somewhat well acquainted with the sprinkler irrigation field. Salary is open and dependent entirely upon the ability of the individual. Opportunities for further advancement are excellent. State background and experience in detail in application. O-235-730

AGRICULTURAL ENGINEER or soils specialist for settler assistance work with new settlers in the Columbia Basin. Employment with Washington State College Extension Service in cooperation with the Bureau of Reclamation. Work consists of complete planning and layout of farm fields and farm irrigation systems, technical advice in clearing farm units, determining the amount of leveling necessary, staking the land for leveling and checking the leveling operation, technical advice and assistance in irrigation practices and use of water control and distribution devices to assure efficient use of irrigation water. Background of soils and agricultural engineering desirable. Also experience on irrigated farm important. Salary range depending upon experience, $3600 to $4500 beginning salary. Six months training period given to all employees. O-244-731

EXTENSION SPECIALIST in wood and metal working, to develop and carry out wood and metal working programs with 4-H Club leaders and members in a midwestern state. Excellent opportunity for a person interested in youth work. Good opportunities for advancement. Salary up to $6,500 for 12 mo, with one month vacation. O-268-732

AGRICULTURAL ENGINEER (rating associate extension agricultural engineer) to handle 4-H tractor program and develop program for adult farmers on choice, use, care, and maintenance of farm machinery and power equipment in an eastern state. Age 26-40. BS deg in agricultural engineering, or equivalent, and MS deg or equivalent qualifying field experience, preferably in extension work or farm equipment sales. Able to talk and work with farm people and the farm equipment industry. Man selected will be fully responsible for extension project in farm power and machinery, and will be associated with an extension staff of six others working on other agricultural engineering subject matter. Excellent opportunity to develop an outstanding program. Annual leave 26 days. Salary increases on merit basis. Starting salary about $5280. O-248-733

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Personnel Service Bulletin

(Continued from page 428)

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER for development, sales, or service in soil and water or product processing field with manufacturer, processor, distributor, consultant, farming operation or trade association, anywhere in U.S.A. Married. Age 34. No disability. BS deg in agricultural engineering, 1949, University of Minnesota. Farm background. Hydraulic engineer with U.S. Geological Survey since graduation. War enlisted and commissioned service in Navy, 4 yr. Available September 1. Salary open. W-179-24

AGRICULTURAL ENGINEER for development and research in soil and water field, with manufacturer or processor, anywhere in U.S.A. Married. Age 40. No disability. BS deg in mechanical engineering, 1940, University of Beograd (Yugoslavia). PhD., 1945, University of Geneva, Switzerland. Military service in Yugoslavia, 1940-41. Experience in research with Monopol of Tobacco, Beograd, University of Beograd, and in Perugia, Italy, 1946-49. Immigrant in U.S.A. Available on reasonable notice. Salary open. W-203-25

AGRICULTURAL ENGINEER for design, research, development or management in power and machinery or soil and water field with manufacturer, trade association or farming operation in Midwest. Limited travel. Prefer some outdoor work. Married. Age 26. No disability. BS deg in agricultural engineering, 1951, Purdue University. Farm background. Soil Conservation Service 6 mo as engineer trainee. Army service 2 yr, including 19 mo as engineering assistant in research and development on automotive equipment. Catalog technician and designer with manufacturer of farm equipment. Available now. Salary $425 mo. W-242-26

AGRICULTURAL ENGINEER for design, development, or research in soil and water field with industry or public service, preferably in Southeast. Prefer moderate traveling. Married. Age 31. No disability. BS deg, 1951, soil conservation and agronomy; MS deg 1952, soil physics and agronomy, both at Ohio State University. Limited farm experience. Tool designer, 3 yr; civil engineering, 2 yr; soils mechanic, 4 mo; soil physics research 2 yr. Currently graduate assistant. Available August 1. Salary $5000. W-247-27

AGRICULTURAL ENGINEER for design, development, or research in soil and water field, with industry or public service in Northwest or Canada. Prefer travel and outdoor work. Married. Age 24. Wear glasses for office work. BS deg in agriculture, 1953. University of Saskatchewan. Farm background. With Canadian PFRA 2 yr in maintenance and development work on irrigation projects. Available on reasonable notice. Salary $3800-4200. W-250-28

AGRICULTURAL ENGINEER for methods development, application of industrial engineering techniques to agricultural production and processing, and supervision of production and processing activities, fields of product processing and farm structures, with processor, distributor, farming operation or public service agency, anywhere in U.S.A. Will consider overseas assignment. Single. Age 26. No disability. BS deg, 1951, MS deg in agricultural engineering, 1955, Rutgers University. Farm background. Graduate research program concentrated on materials handling aspects of artificial drying of crops. Additional experience in supervision of construction activities, site planning, structural rehabilitation, maintenance of facilities, coordination between contractors, supervision of skilled and unskilled labor crews, instruction in surveying and land reclamation course laboratory. Commissioned service in U.S. Air Force 21 mo, partly overseas with responsibility for truck fleet operations in mass handling of bulk and packaged building materials, vehicle repair parts, earthmoving equipment and spare parts. Available on 30 days notice. Salary open. W-252-29

AGRICULTURAL ENGINEER for college teaching and research in rural electric field, anywhere in U.S.A. Married. Age 43. No disability. BS deg, 1940, University of New Hampshire. MS deg, 1952, Virginia Polytechnic Institute. PhD expected September 1955, Cornell University. Experience one year as teacher of vocational agriculture. Research assistant and instructor 1948-55. War noncommissioned and commissioned service 5 yr. in U.S. Air Force Communications. Available September 15. Salary open. W-245-30

AGRICULTURAL ENGINEER for development, sales, service or management in power and machinery, soil and water, fertilizers or agricultural chemicals, with manufacturer, processor, distributor, consultant, farming operation, or trade association, preferably West Coast or foreign but will consider other locations. Willing to travel. Married. Age 25. Slightly disabled right hand. BS deg in agricultural engineering, 1951, Oregon State College. Work completed for M Ag deg in agricultural engineering, soils, and economics. Farm background. Summer work as mechanic and as weed control research assistant. Present work, plant manager and salesman for aqua ammonia and agricultural chemicals plant. Available on 30 days notice . Salary $450 mo. W-263-31

AGRICULTURAL ENGINEER for design, development, or research in power and machinery or rural electric field with industry or public service, anywhere in USA. Married. Age 25. No disability. BS deg in agricultural engineering, 1953. University of Massachusetts. New England dairy farm background. Agent, USDA farm electrification section, 9 mo. Operated father's dairy farm 6 mo, during his illness. Instructor in research, forage harvesting mechanization, University of Massachusetts, 6 mo. Available after July 1. Salary $400 mo. W-208-32

Research Projects in Agricultural Engineering

(Continued from page 422)

West Virginia University, Morgantown

Investigation to Determine the Optimum Stall for Dairy Cows, R&M No. 5; 1947

To Determine the Most Efficient and Economical Methods of Removing Manure and Litter from Dairy Barns, R&M No. 6; 1947

Factors Involved in the Use of Supplemental Irrigation Under West Virginia Conditions, R&M No. 24; 1954

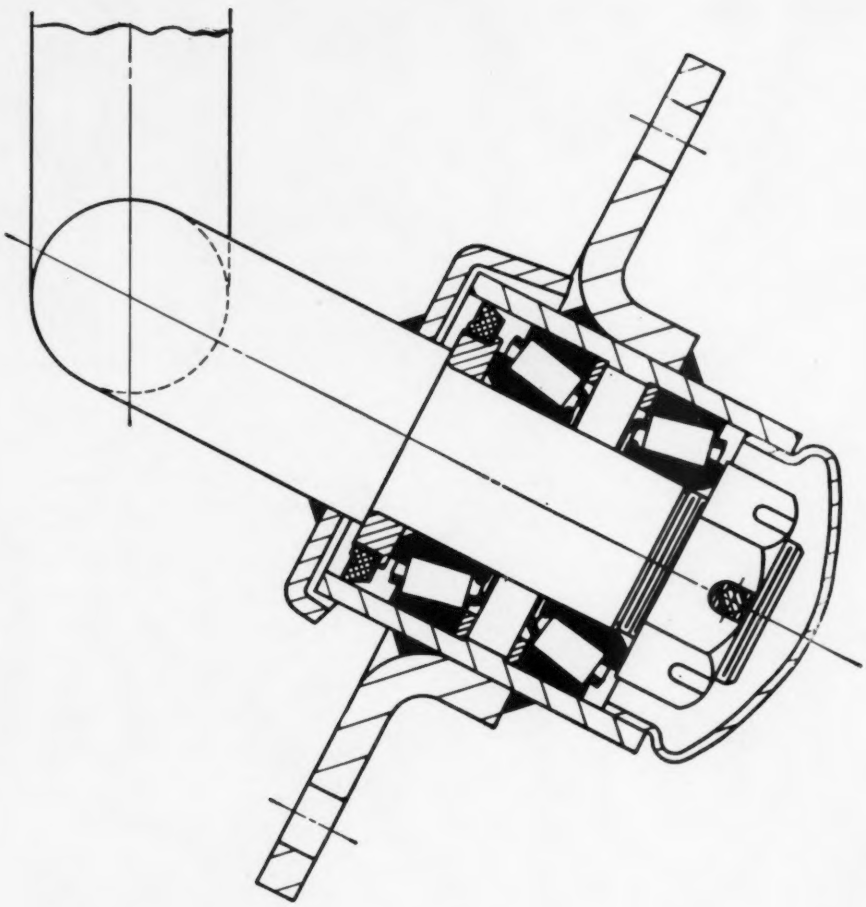
Poultry House Design for West Virginia (NE-8) R&M No. 44; October 1953

The Mechanization of Forage Crop Harvesting, Processing, Storing, and Feeding (NE-13), R&M No. 48; July 1954

Index to Advertisers

Professional Directory

How I-H Engineers Handle Thrust Loads, Eliminate Wheel Hub Machining on Plow Furrow Wheel



WHEN International Harvester engineers developed this new rear furrow wheel, they didn't have one problem to solve—they had four. How to handle tremendous thrust loads while operating in deep dirt; how to keep that dirt out of the bearings; how to design a bearing assembly that would permit the plow to be towed at full tractor speeds on the open road; how to cut production costs. One engineering feature solved all of these problems. The engineers mounted the wheel on Timken® tapered roller bearings.

Timken bearings not only handle the tough thrust loads, but the radial load as well. Their tapered construction enables them to take any combination of thrust and radial loads. More effective closures are possible because Timken bearings hold housings and shafts concentric. Dirt stays out—lubricant stays in.

Ease of operation is assured whether the plow's being towed to the job or pulled in the field. The true rolling motion and precision manufacture of Timken bearings practically eliminate friction.

And manufacturing is one step simpler, too. For this special application, a tube assembly is furnished by the Timken Company and the tube is welded to the flange.

Wheel hub machining is completely eliminated.

For more information, write now for your free copy of "Timken Roller Bearing Practice in Current Farm Machinery Applications". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

The farmer's assurance of better design

TIMKEN Tapered Roller BEARING EQUIPPED

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL AND THRUST → ← LOADS OR ANY COMBINATION